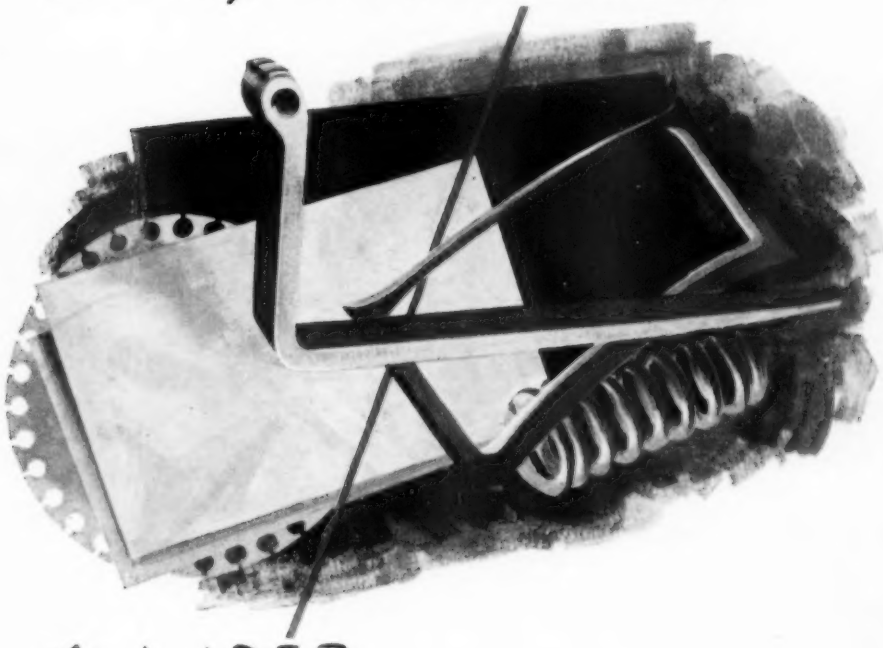
Sheet Metal Industries

The only Journal in the World wholly devoted to the Manufacture, Manipulation, Fabrication, Welding, Assembly and Finishing of Ferrous and Non-Ferrous Sheet and Strip

VOL. 37 : No. 399 JULY 1960 PRICE 2/6

When they talk about MOTORING—



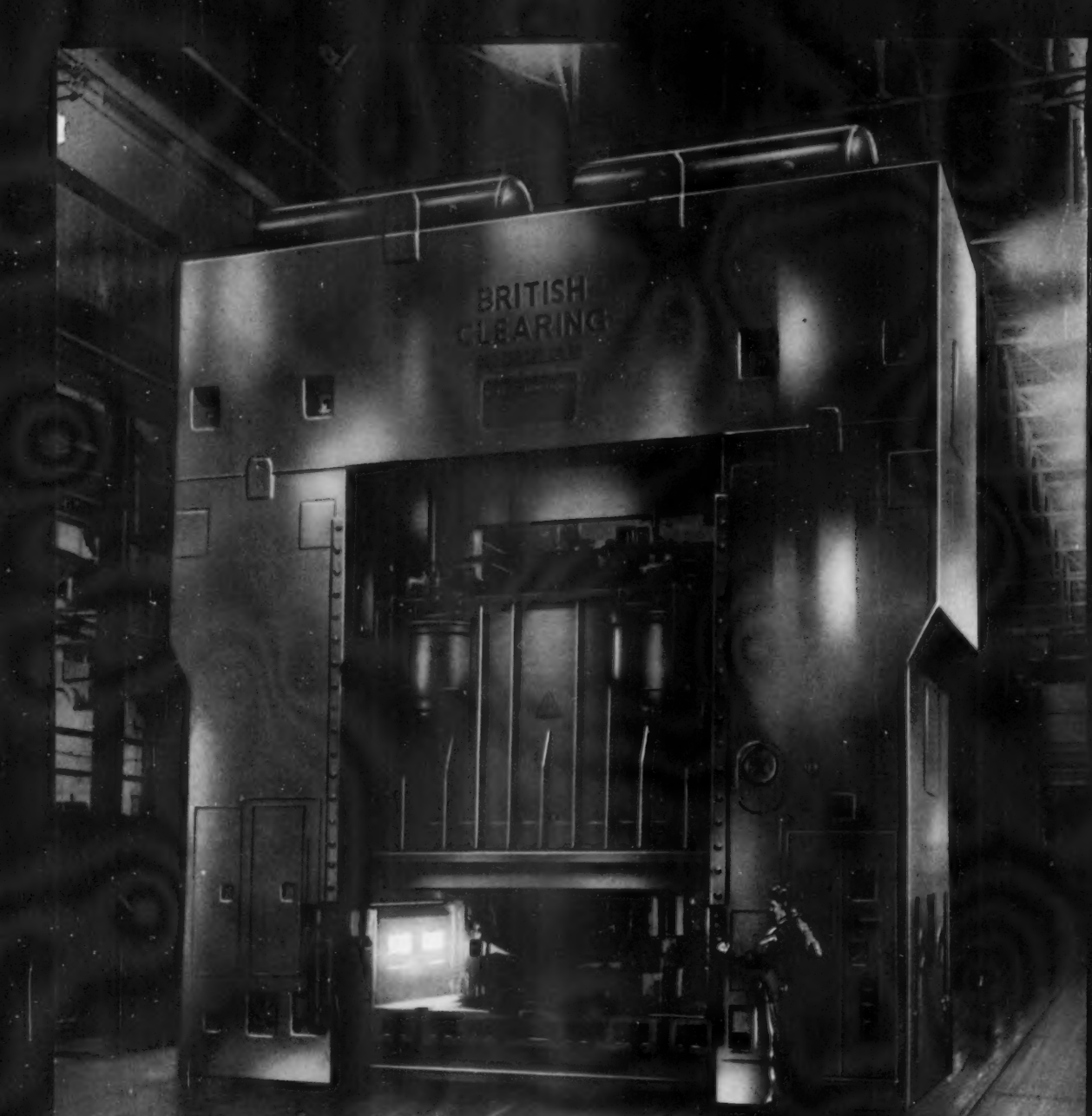
think of R·T·B

The steel frames of their car seats are probably pressed from RTB sheet, so are the bodies; the springs of the independent suspension may be made of our alloy steel; so are the 'strong arms' of the fork-lift trucks used by the motor-car manufacturer.

The artist's sketch shows finished parts made from RTB steel—against some steel plate, autobody sheet, and ternecoated sheet.

And at home they are served by tinplate, bright sheets and black steel sheets. Hardly a household has less than a hundred examples; and not far away are RTB laminations, generating electricity or turning it into power.

Richard Thomas & Baldwins Ltd R·T·B



BRITISH CLEARING Presses used by
Ford Motor Company Ltd., Body Division

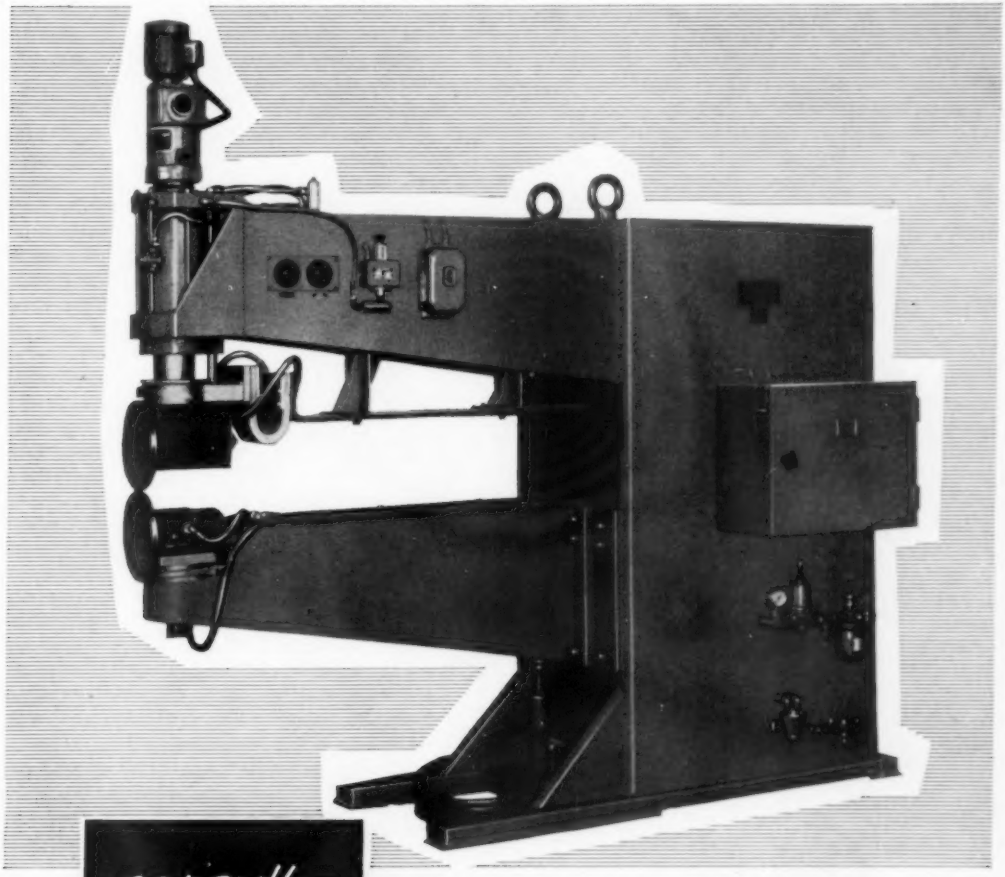
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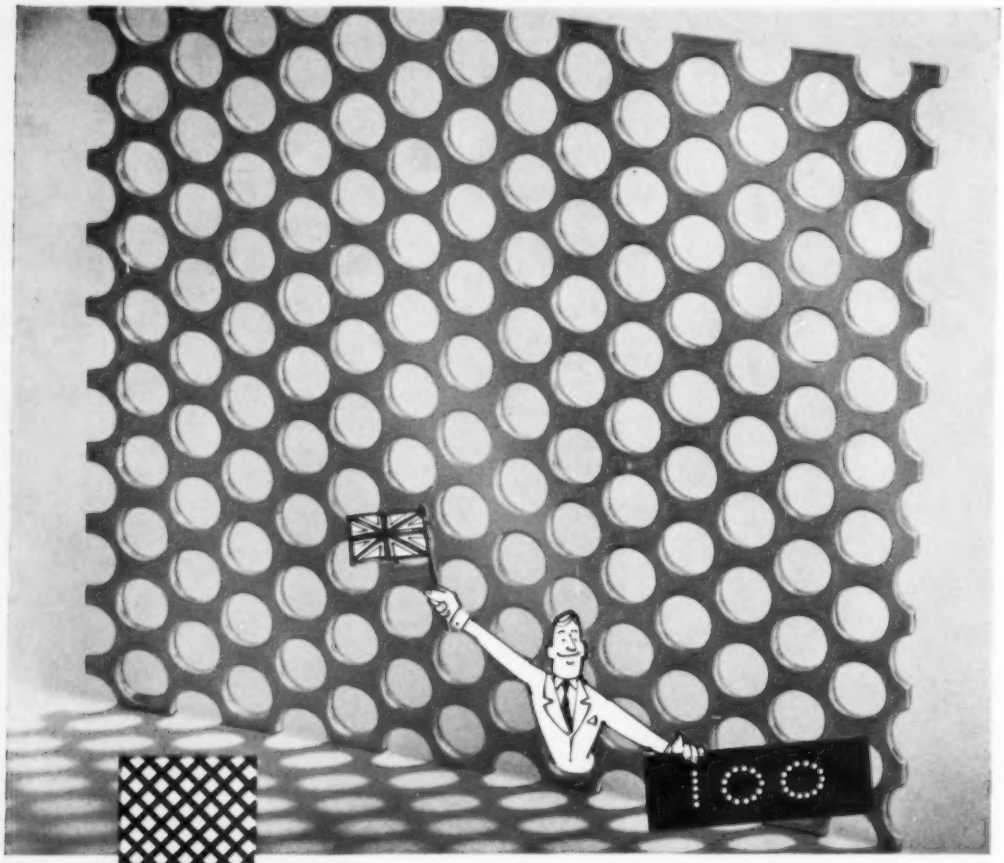
WHATEVER THE SHAPE OR SIZE, ASEAWELD HAVE A MACHINE TO GET ROUND IT

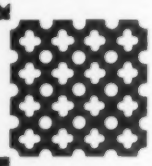
Seam welders with long throat—short throat—deep throat—adjustable throat. Pedal operated—air operated. One wheel driven—both wheels driven. Travelling heads—rotating heads. Travelling jigs—rotating jigs. Circular seams—longitudinal seams (down to 4" dia. on standard machine). Aseaweld makes them all, with infinite speed regulation on all types.

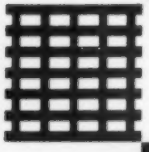
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Classified Advertisement pages. 121







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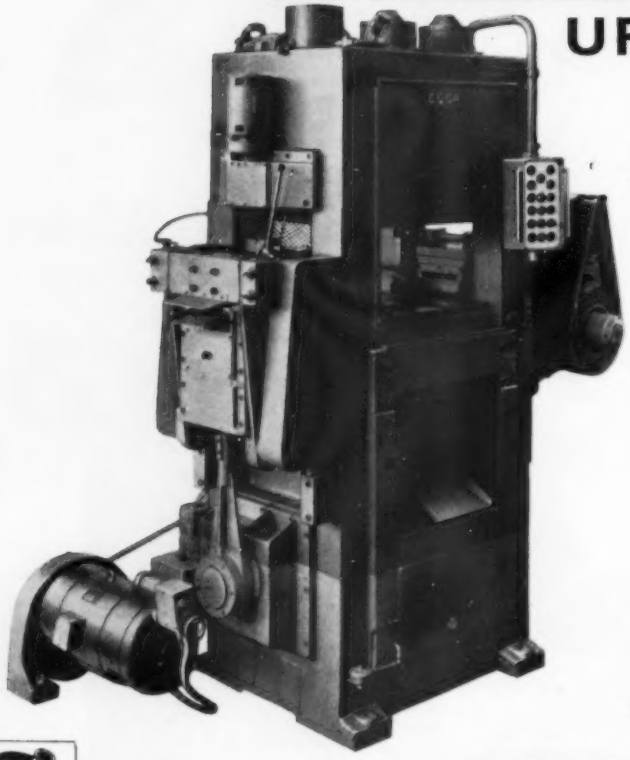
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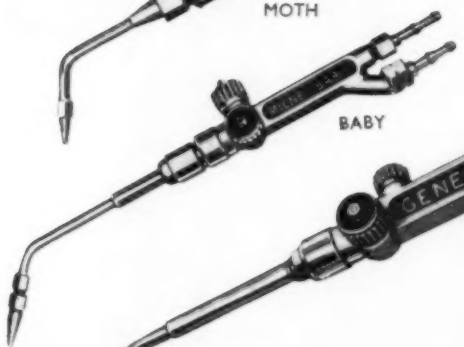
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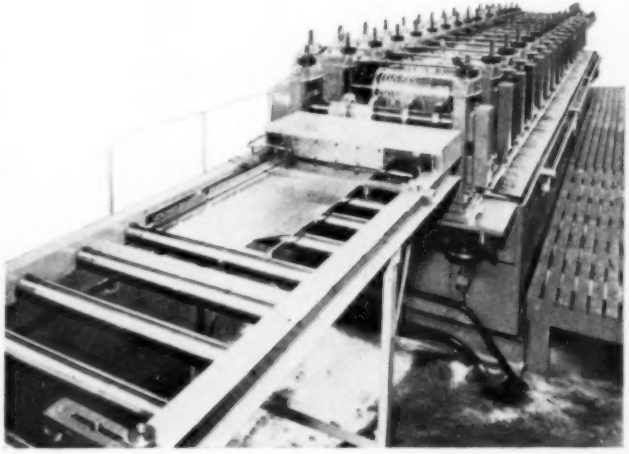
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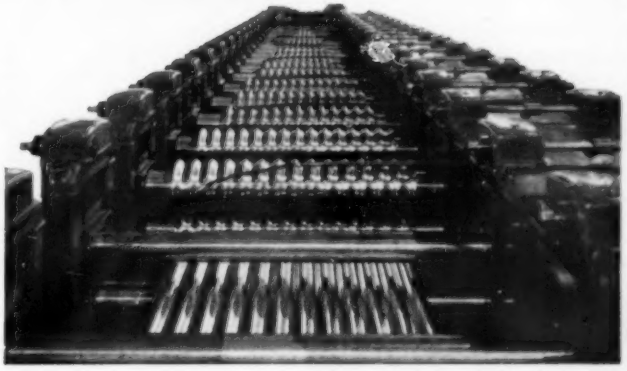
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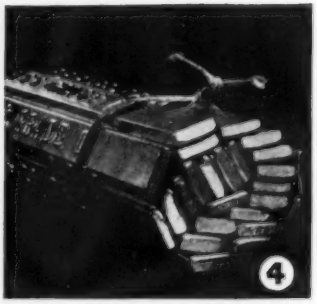
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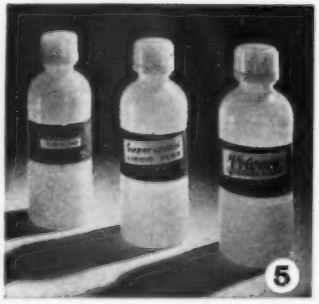
A few examples from a wide range of solders and solder products manufactured by Enthoven. If there's a soldering job to be done, there's an Enthoven product to do it — a product which stems from 150 years experience and 'know-how' in non-ferrous metals.

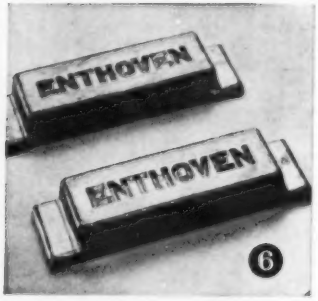


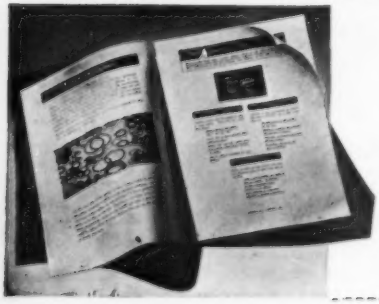


If you use solder you should contact Enthoven who will be pleased to assist you technically in addition to supplying the finest quality materials.

As a first step why not send for our booklet on ENTHOVEN SOLDER PRODUCTS.



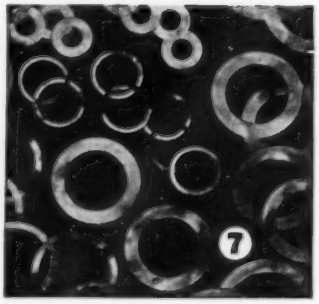




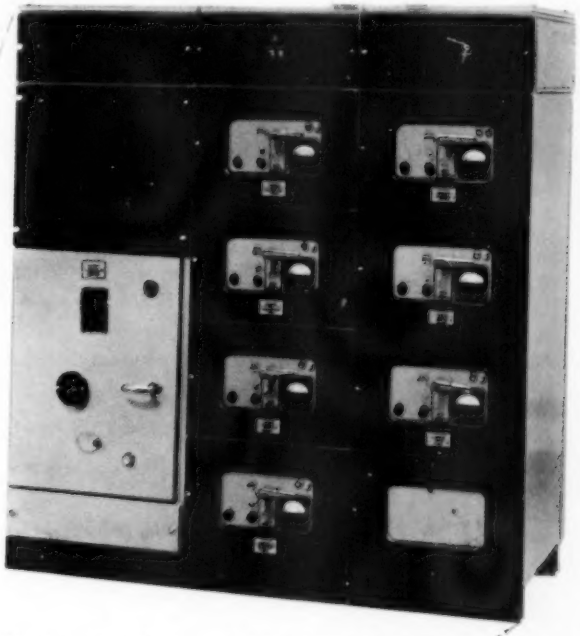
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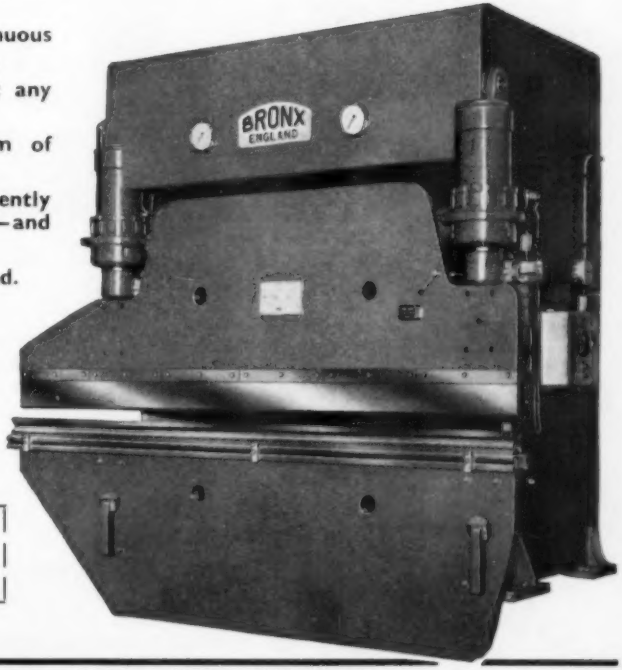
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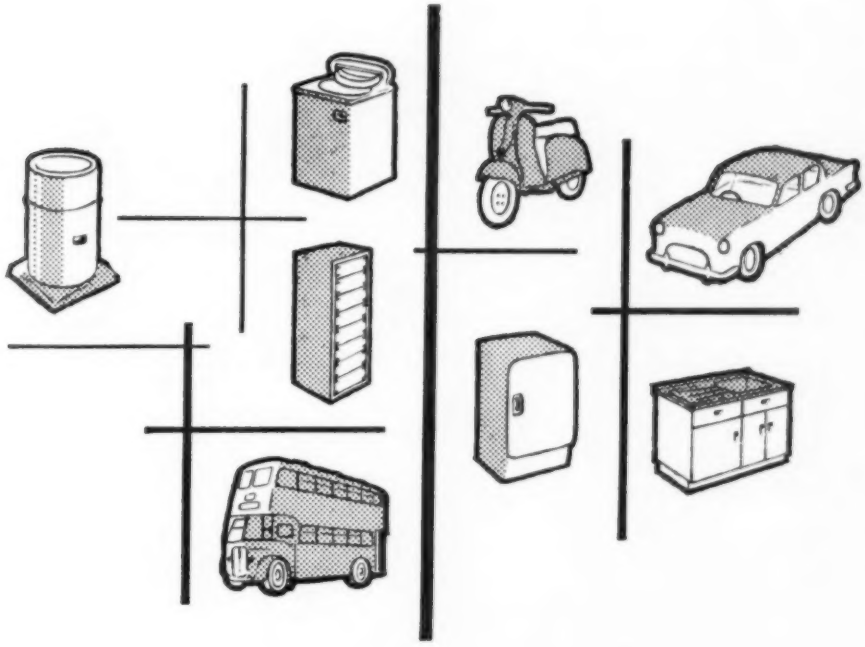
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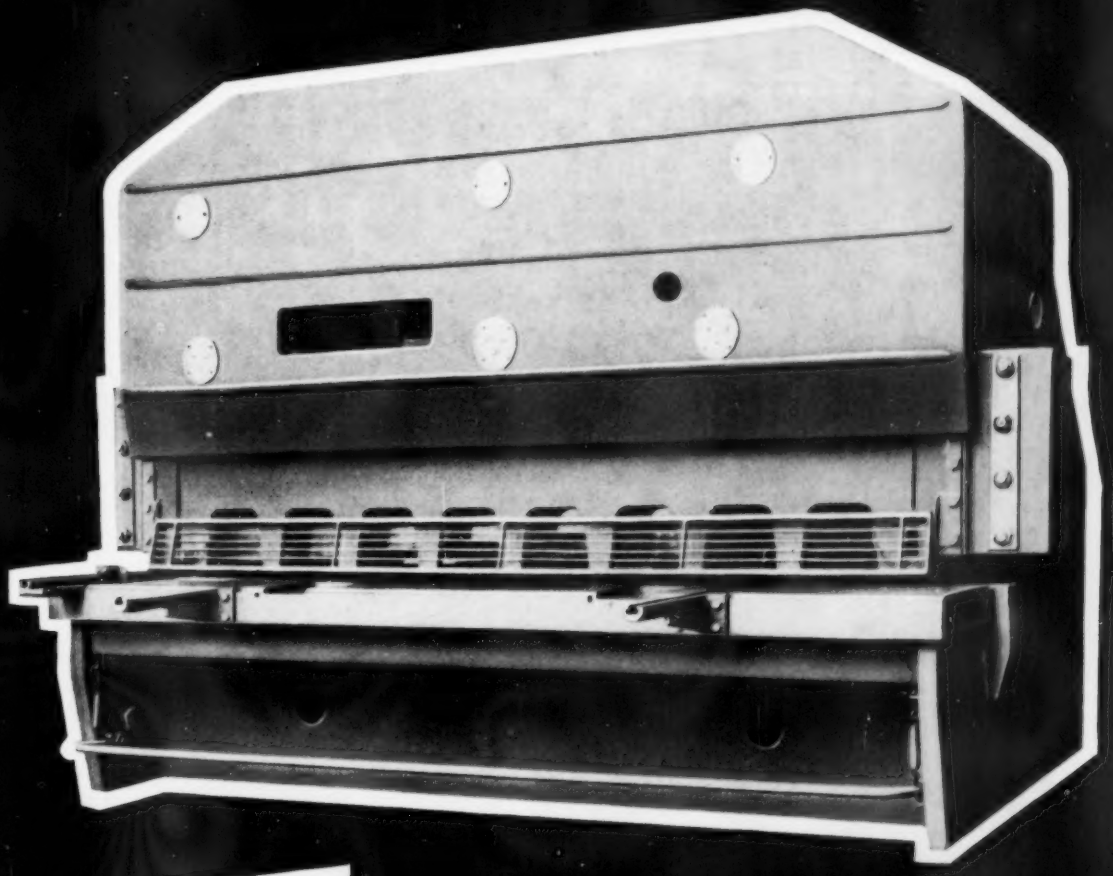
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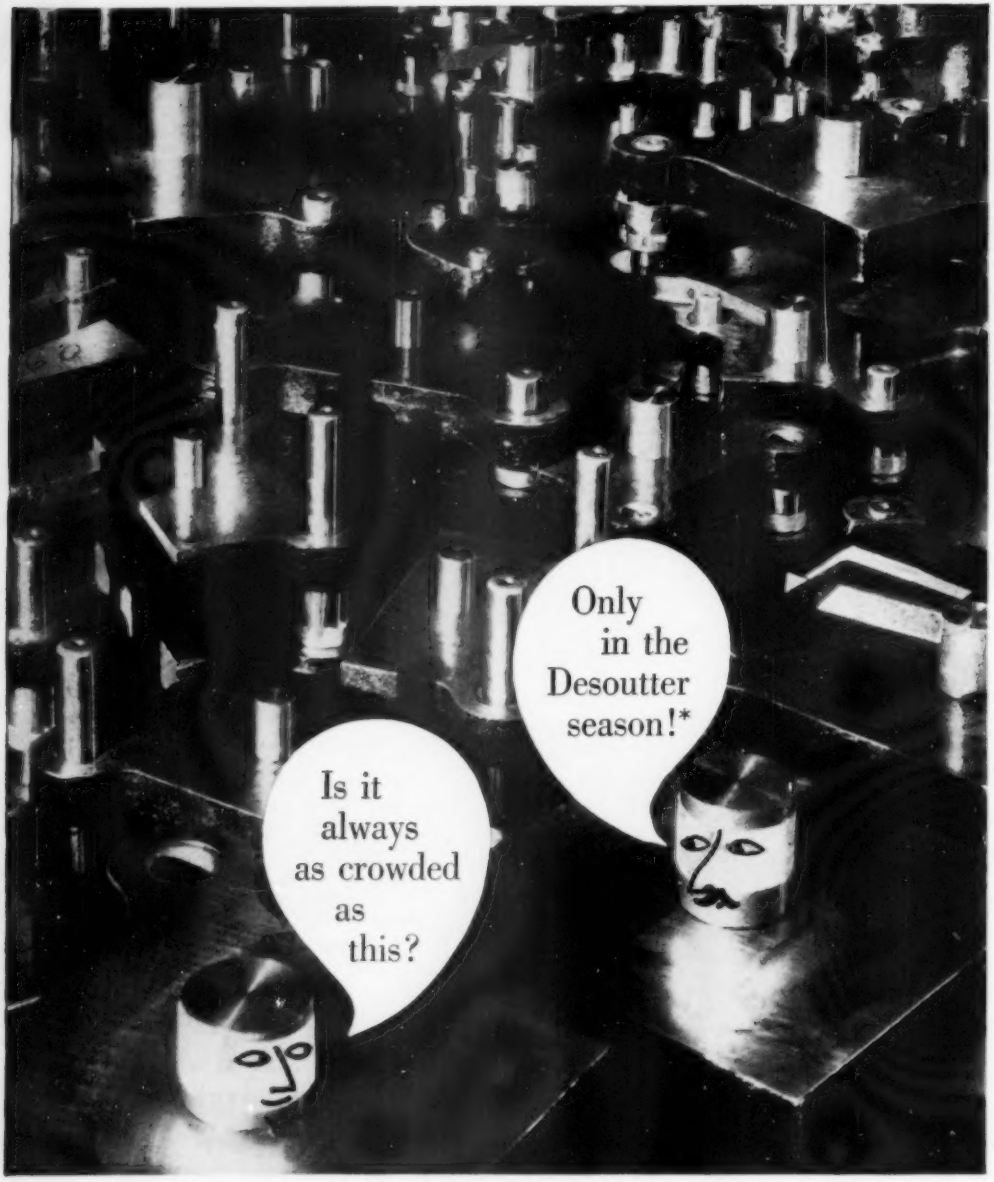
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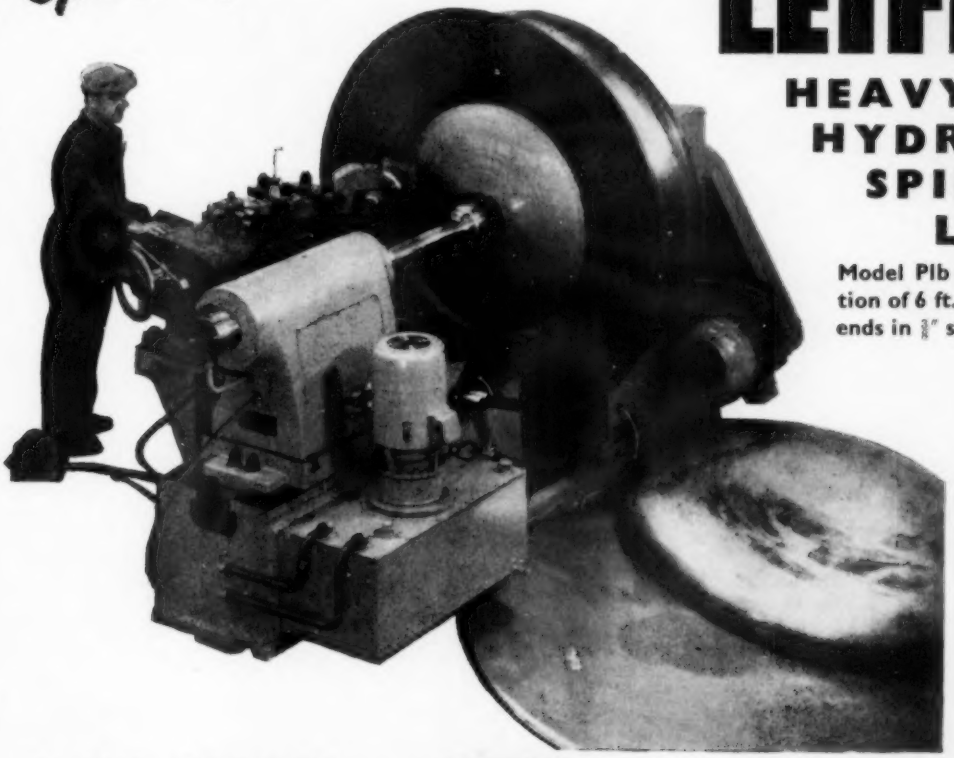
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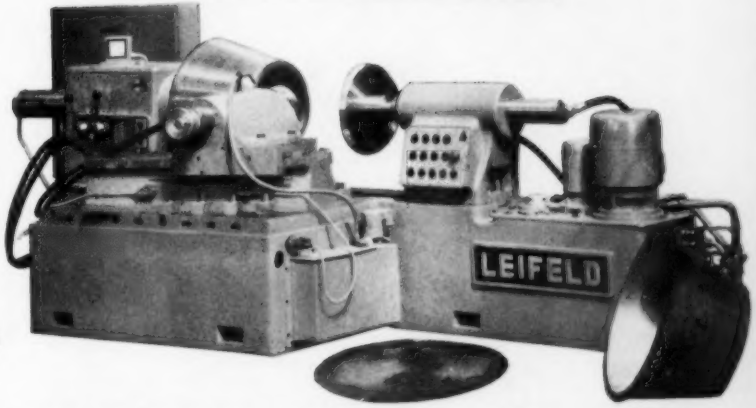
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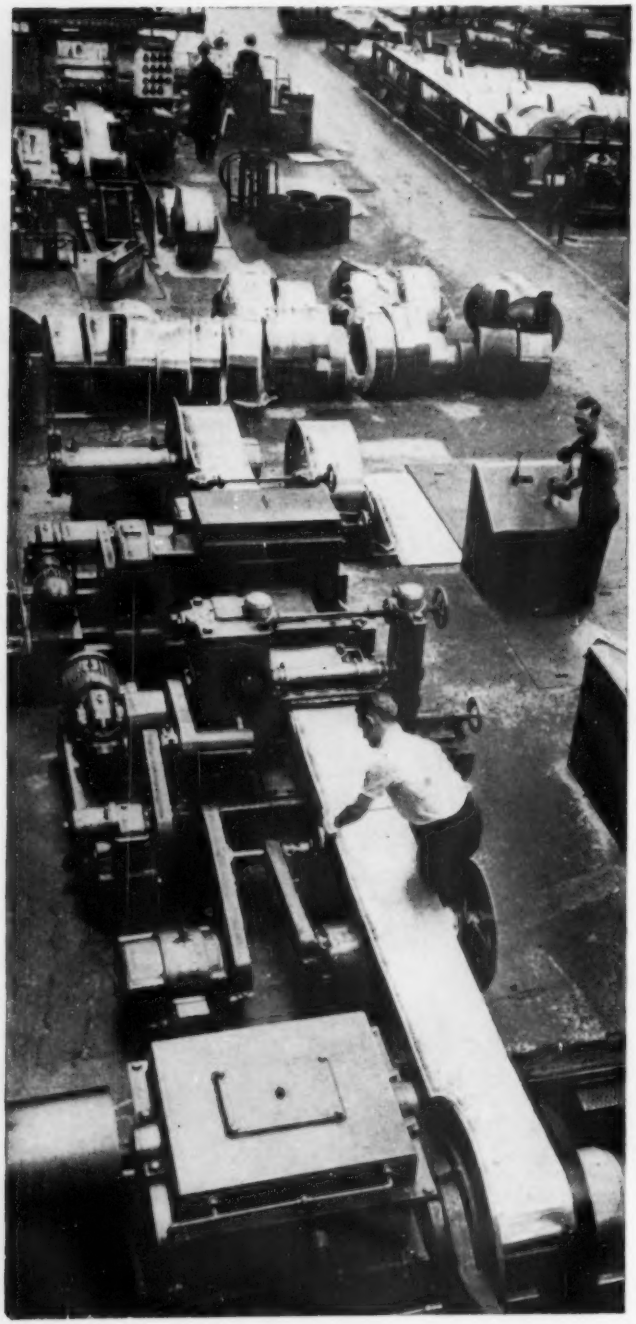
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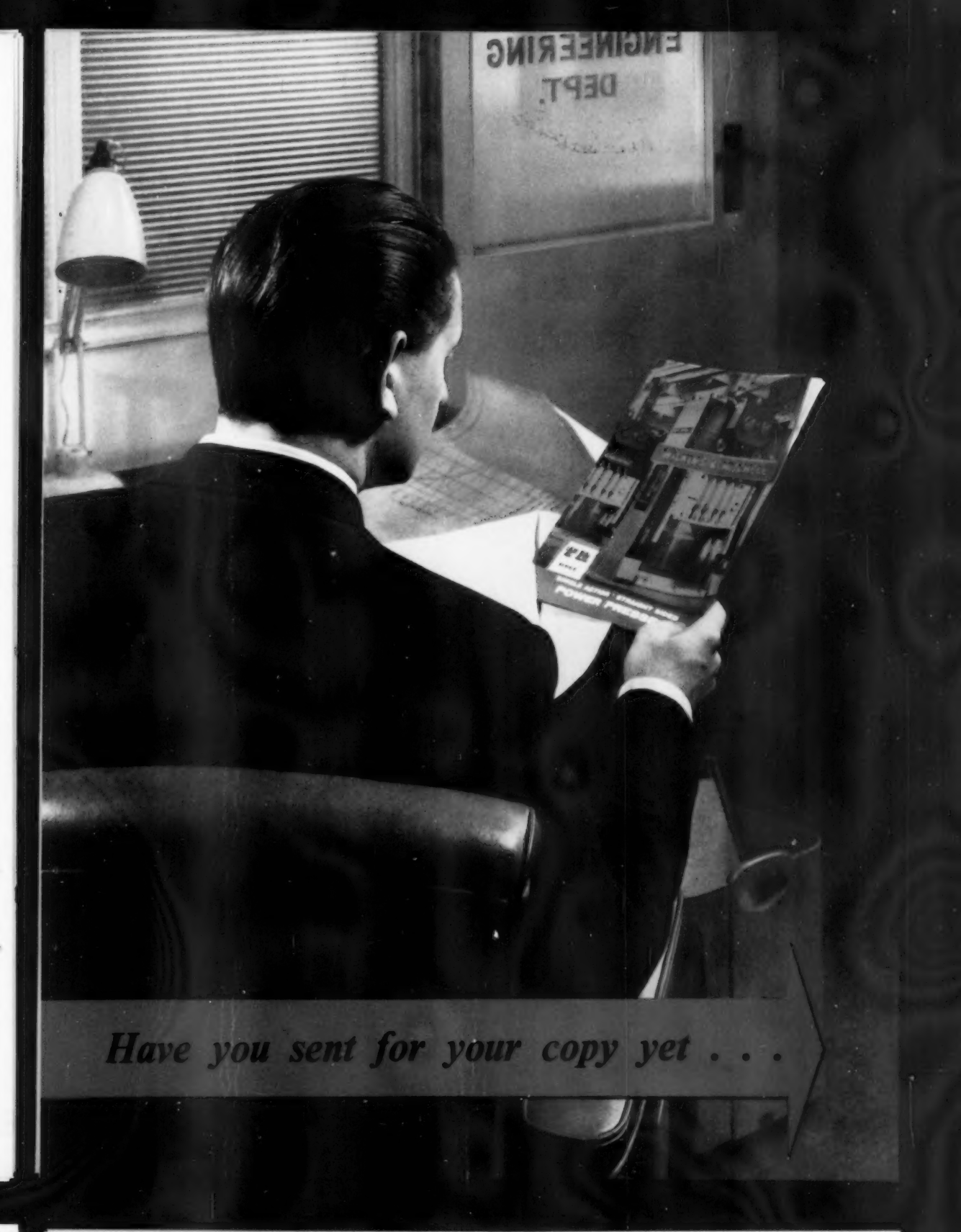
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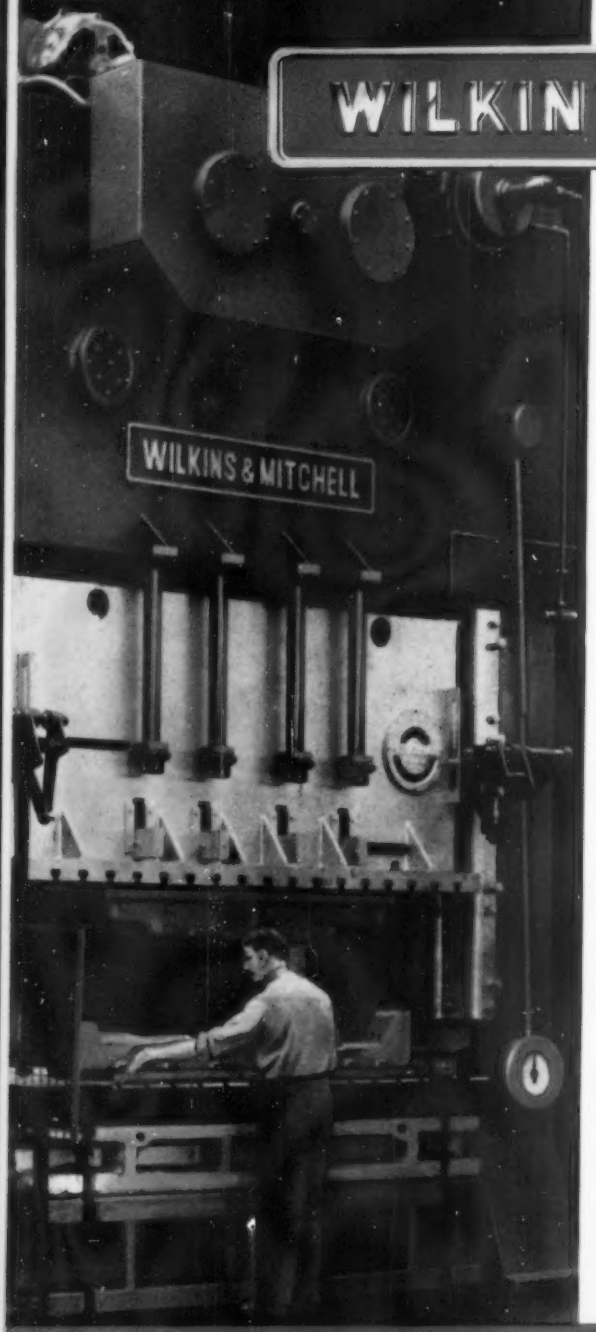
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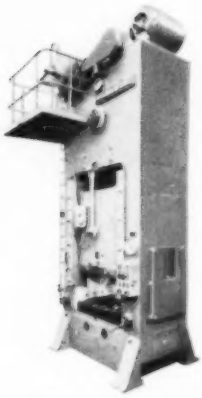
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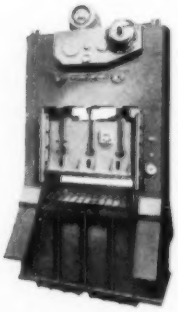
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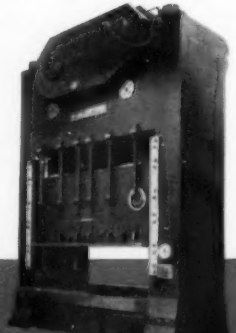
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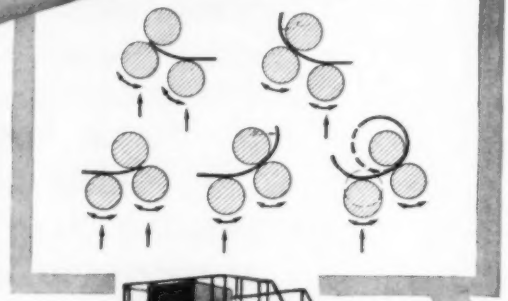
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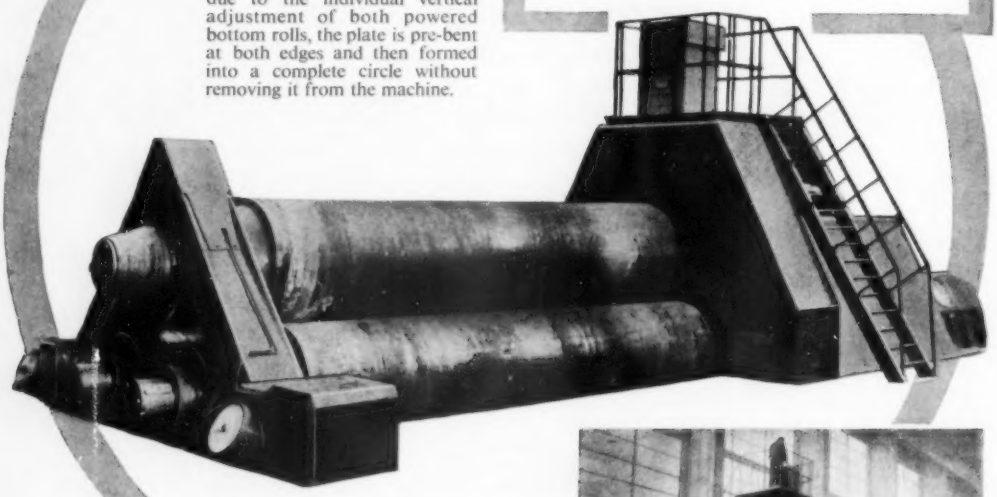
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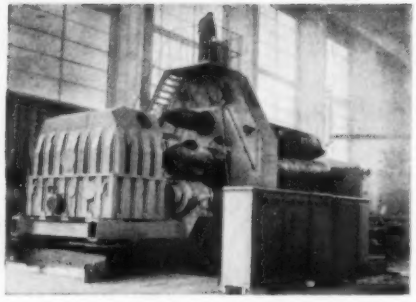
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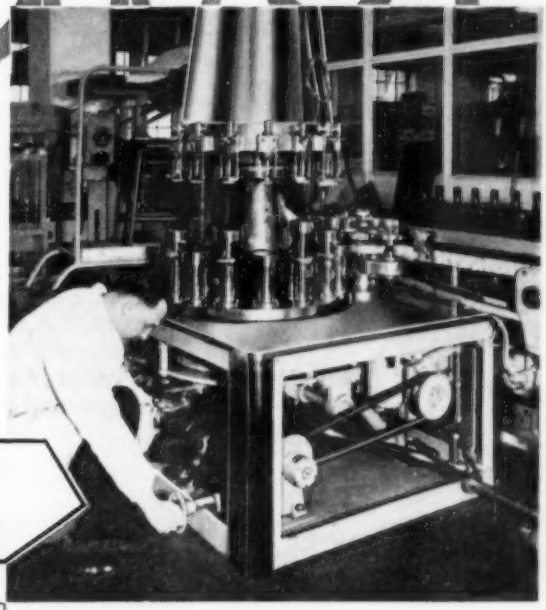
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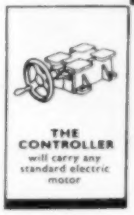
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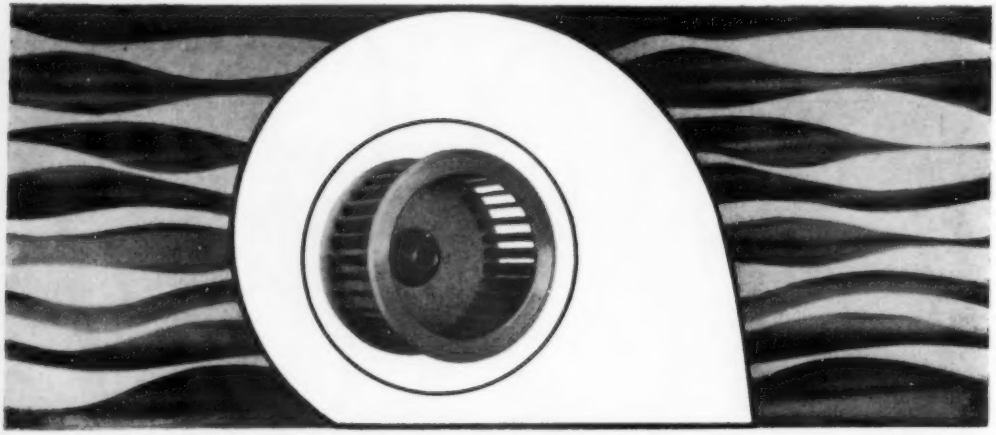
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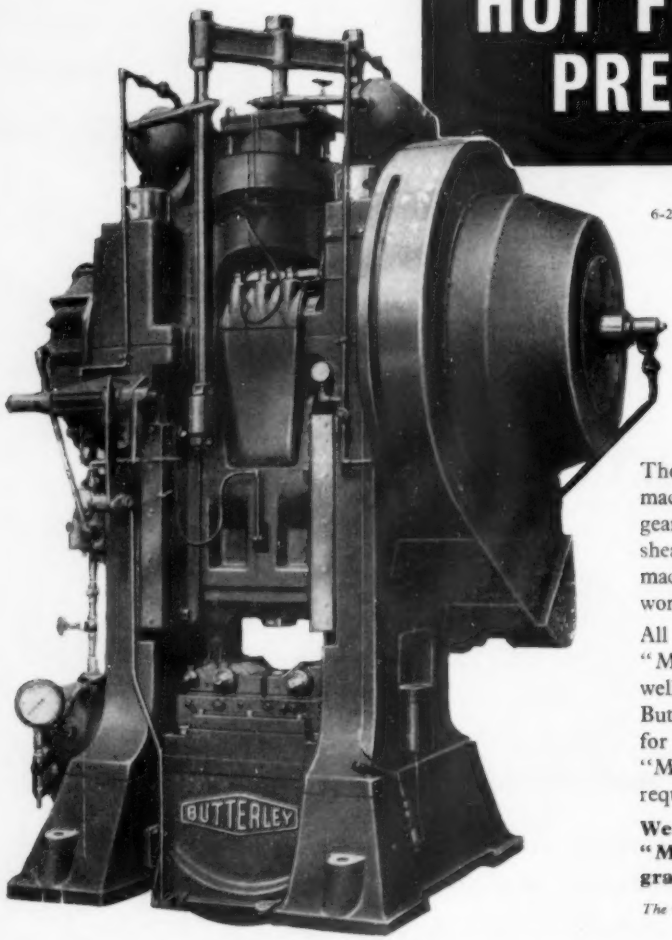
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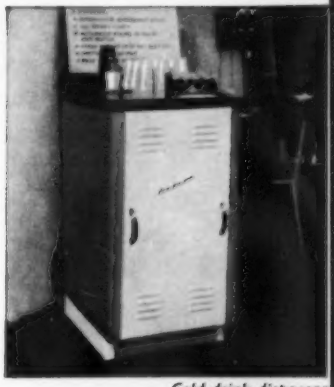
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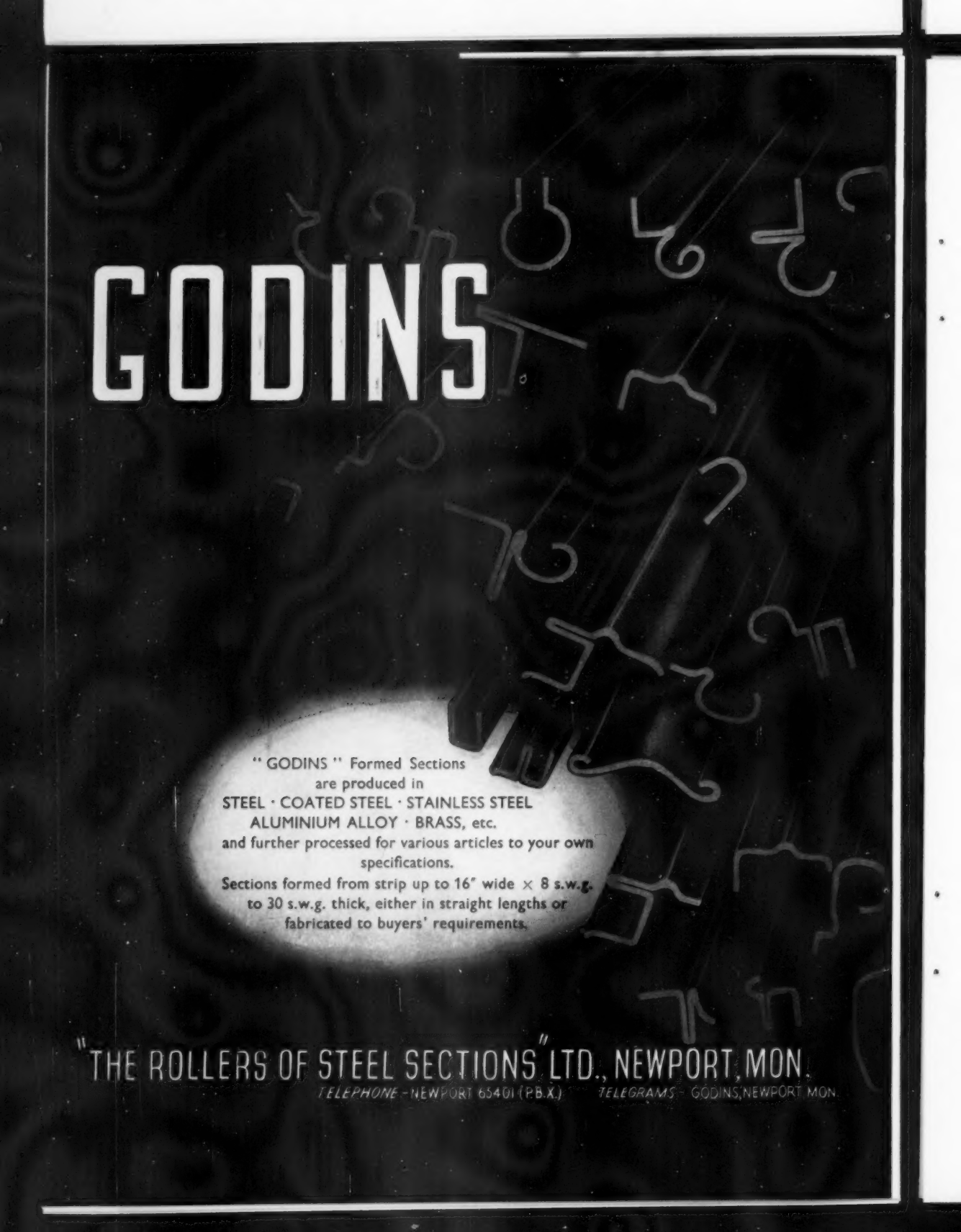


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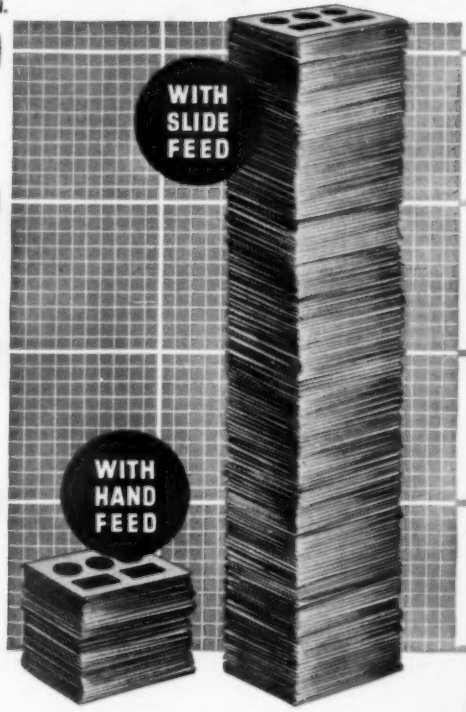
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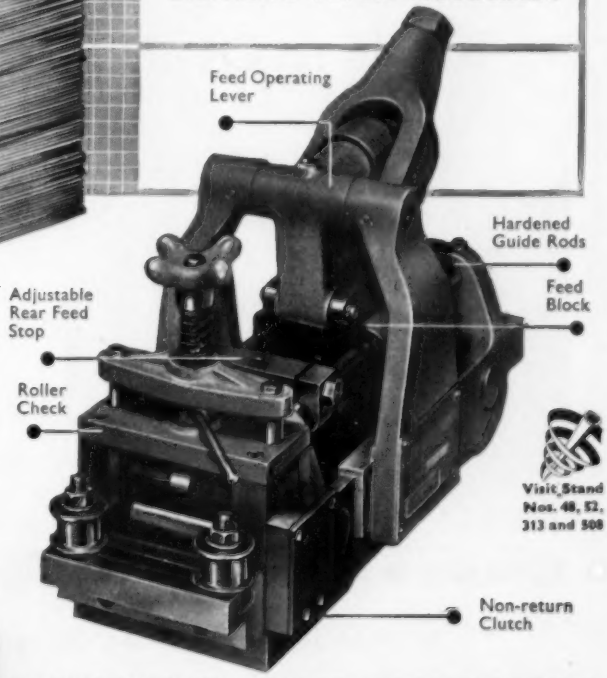
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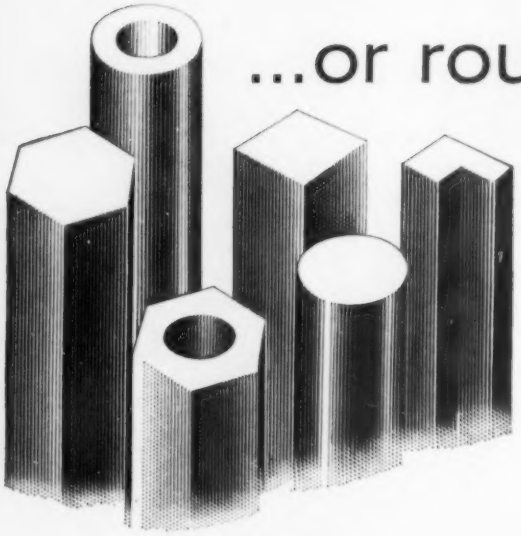
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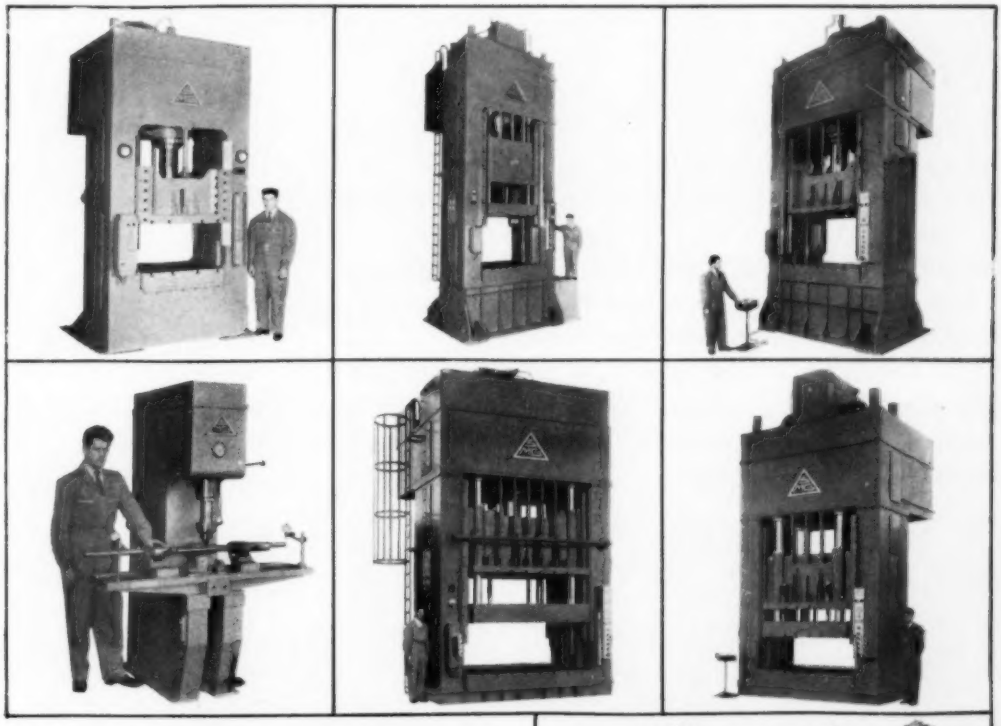
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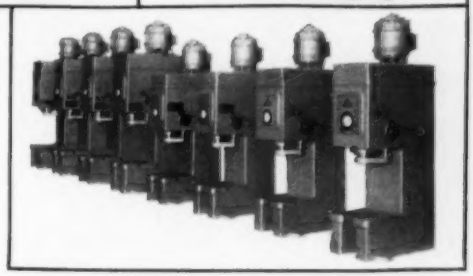
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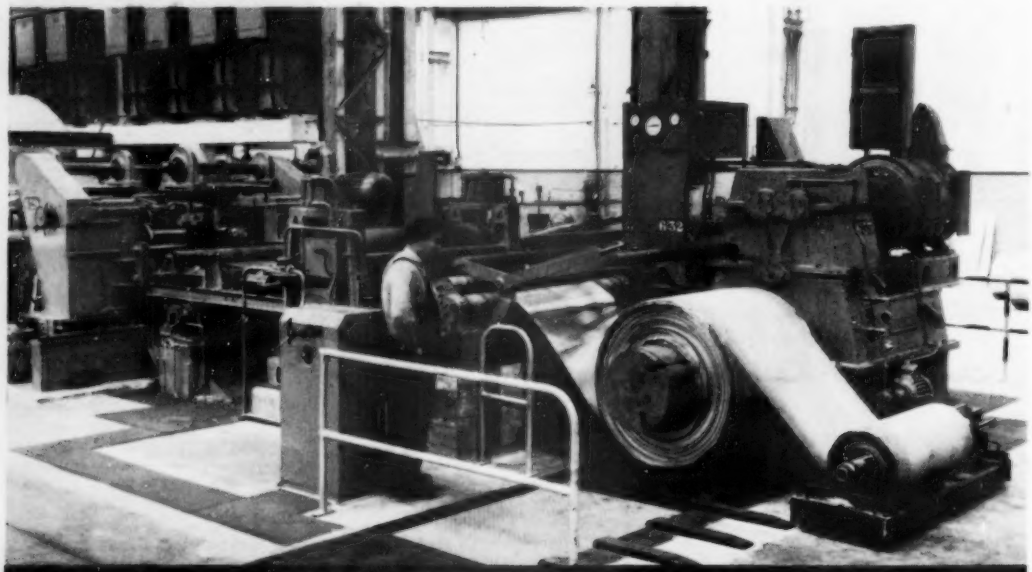
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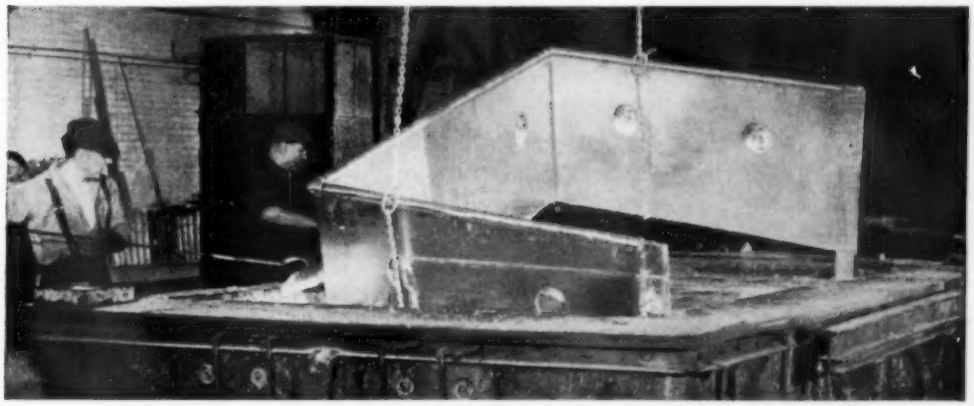
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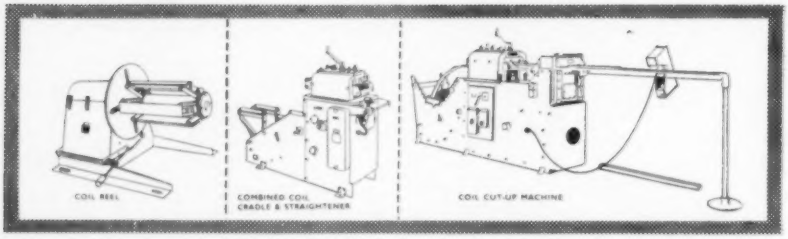
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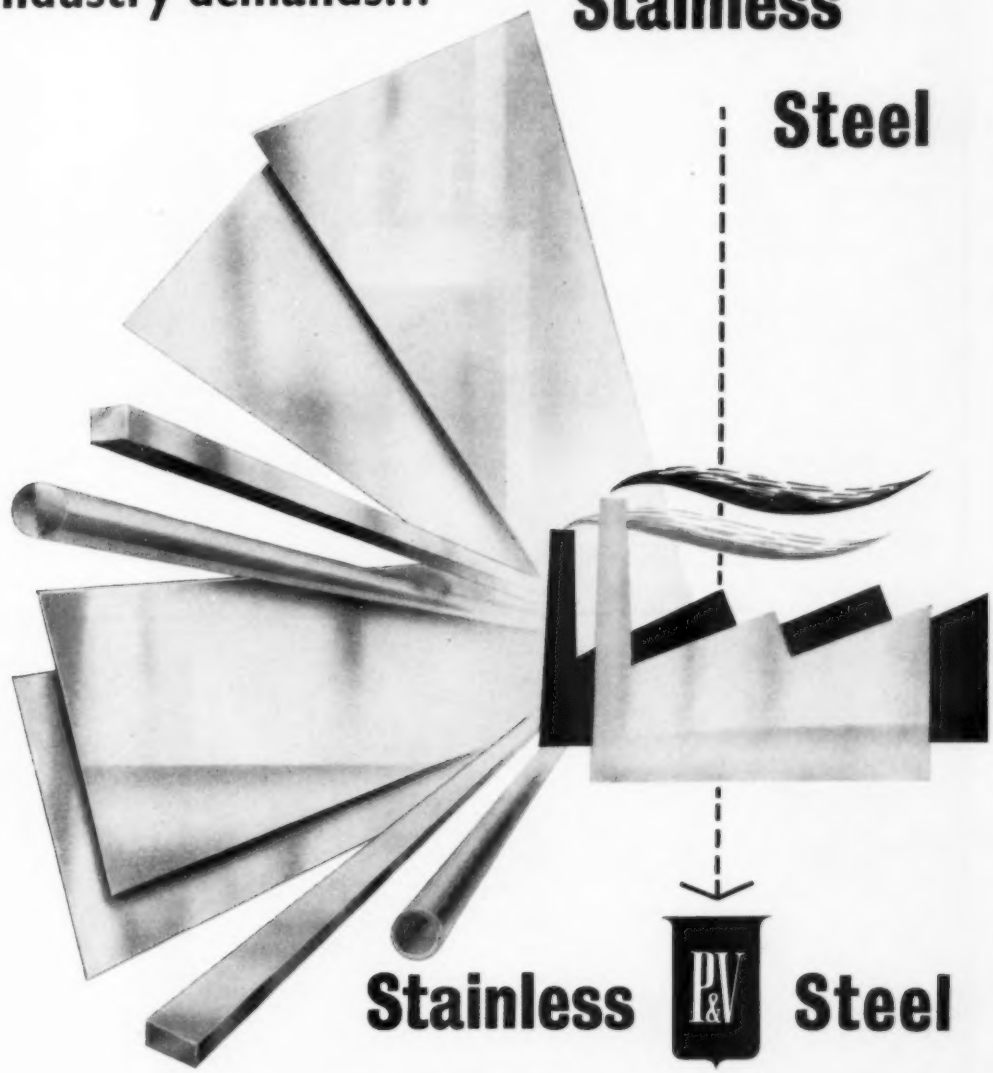
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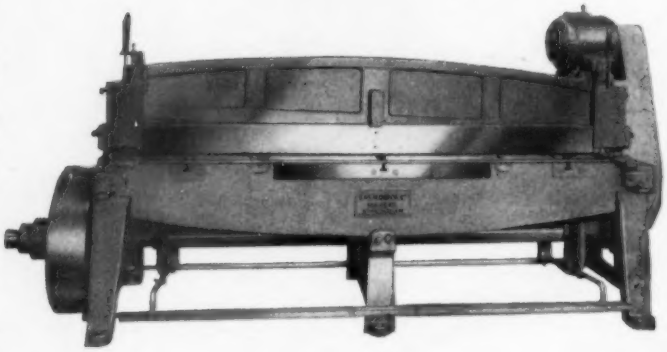
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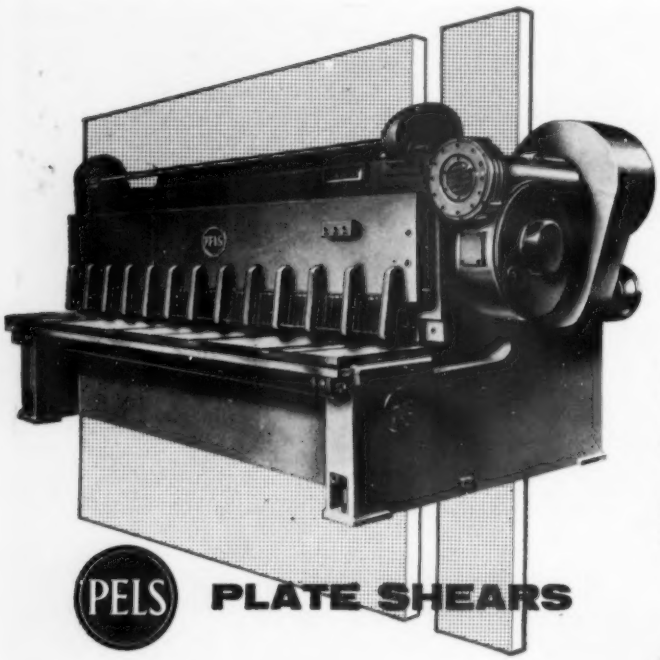


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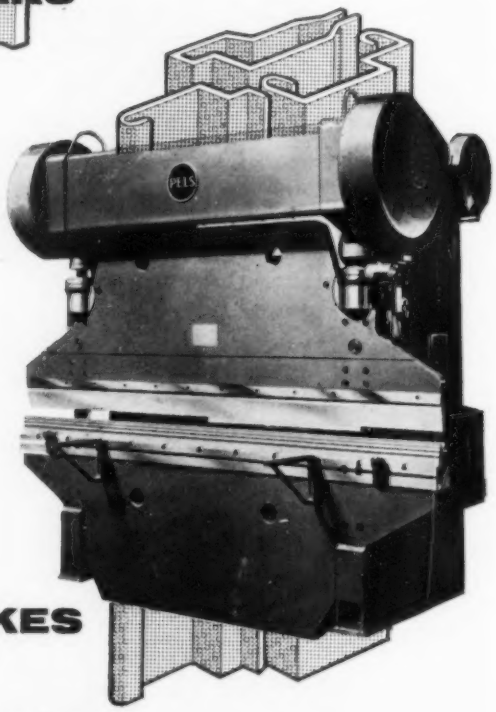


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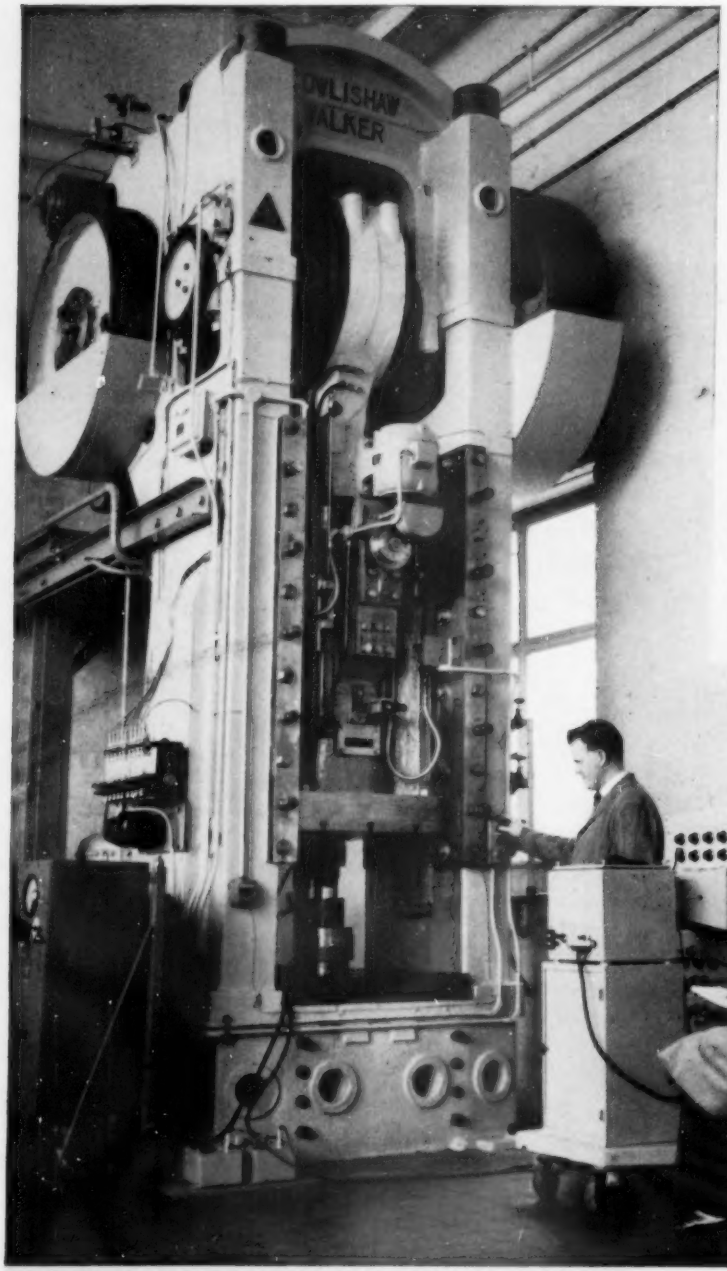
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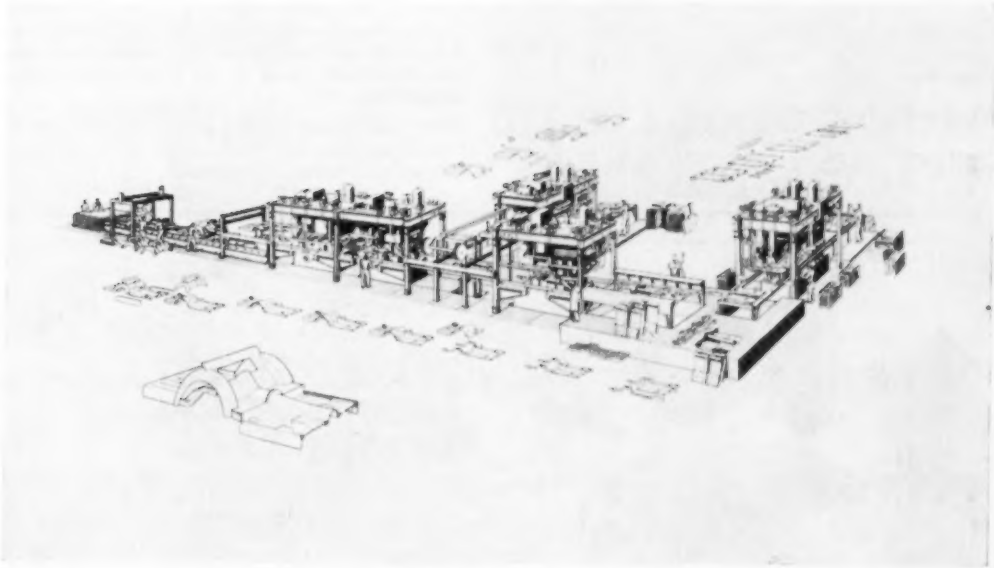
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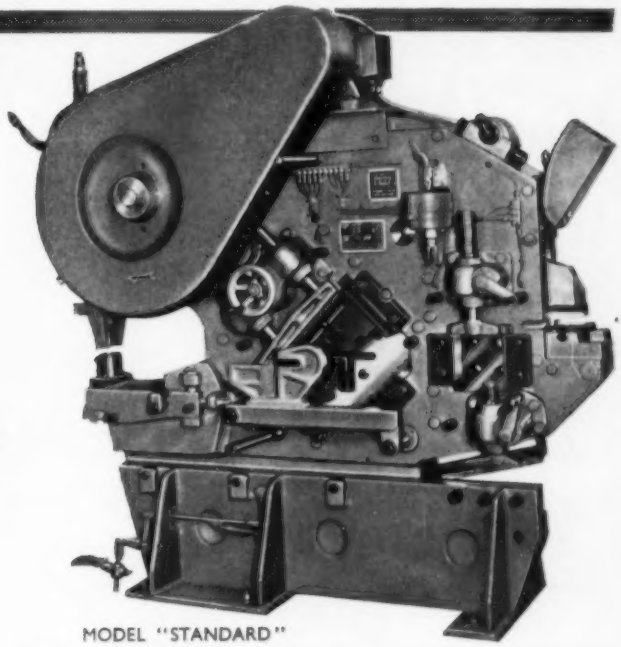
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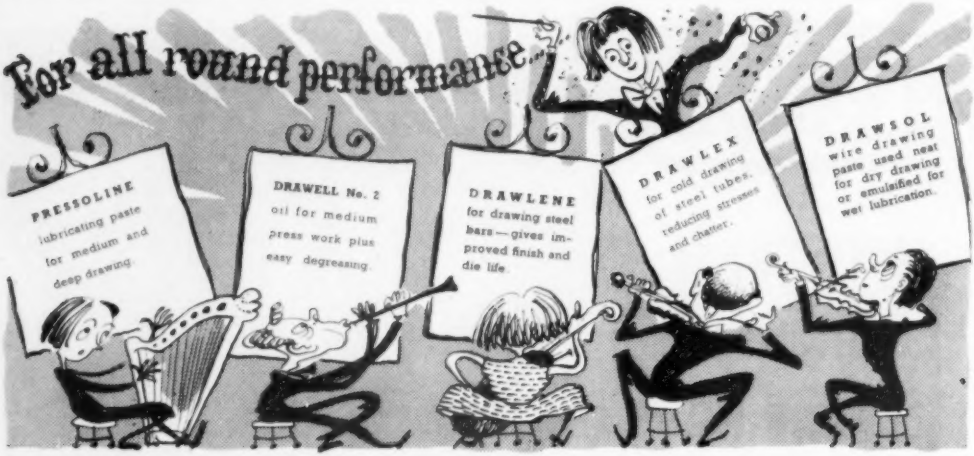
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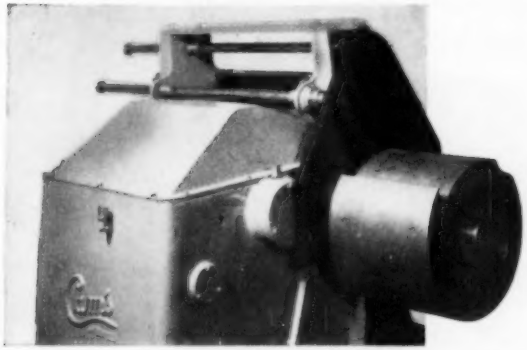
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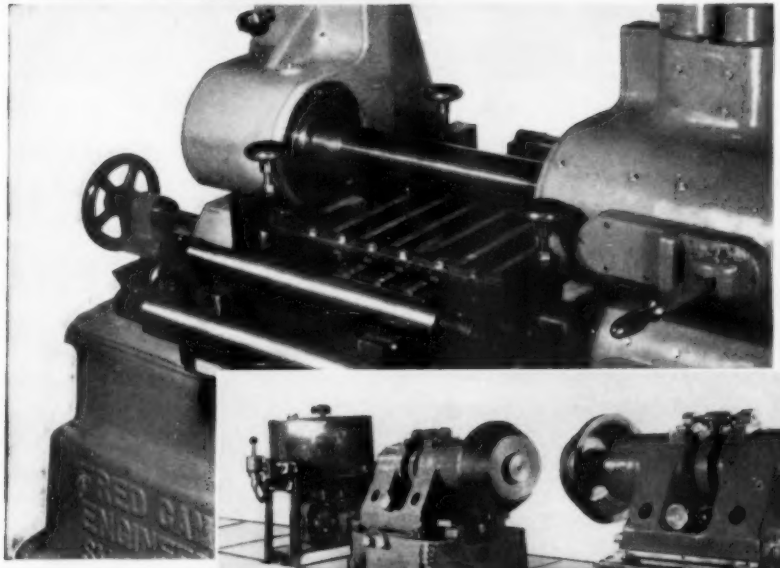
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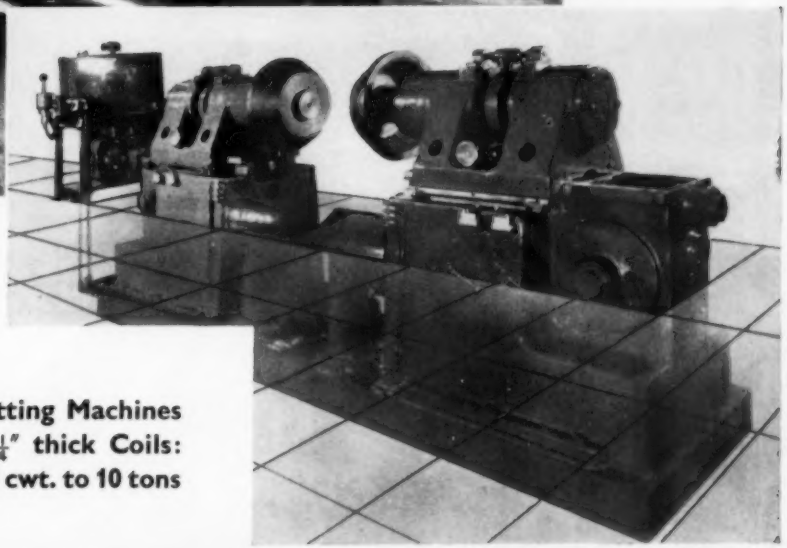
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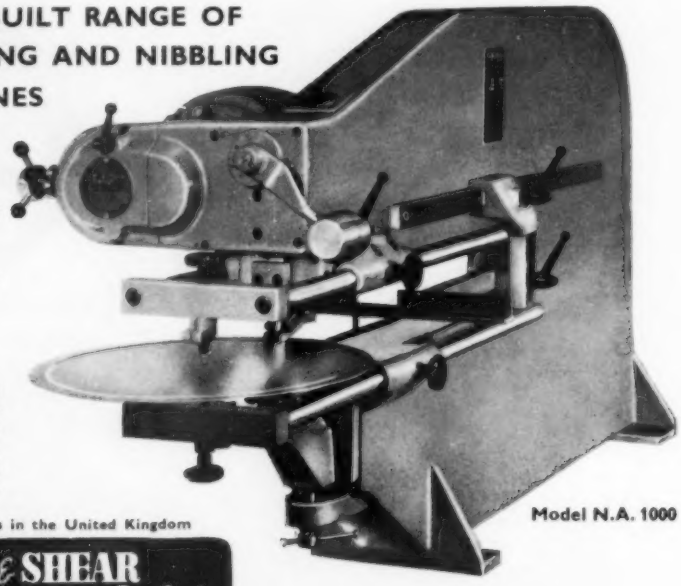
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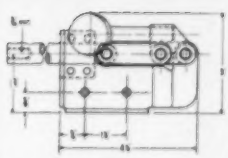
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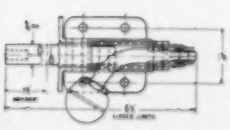
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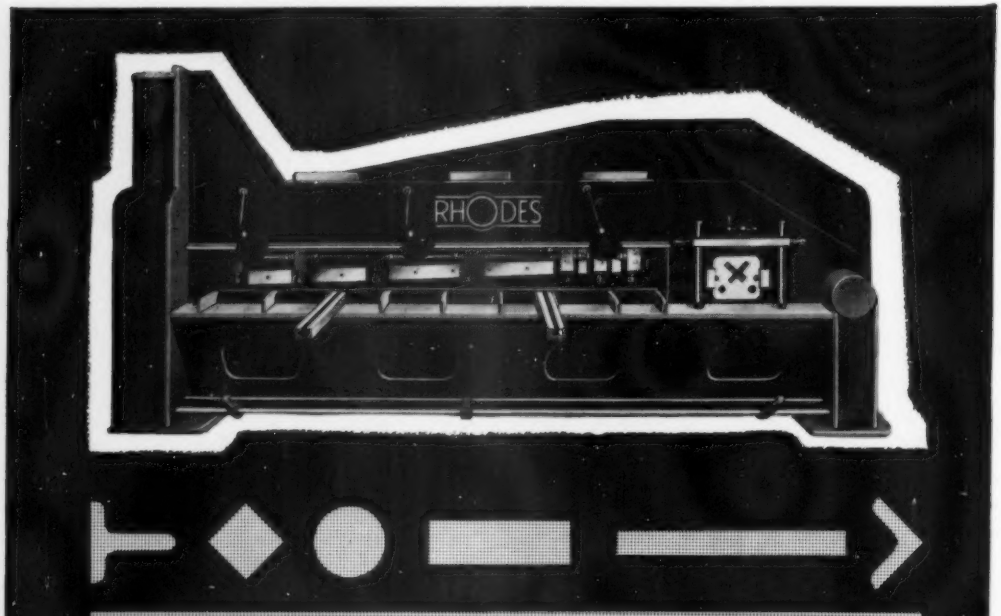
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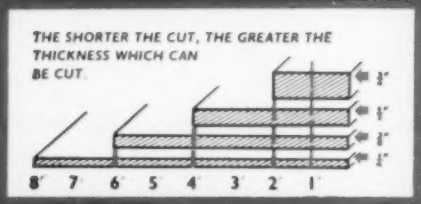
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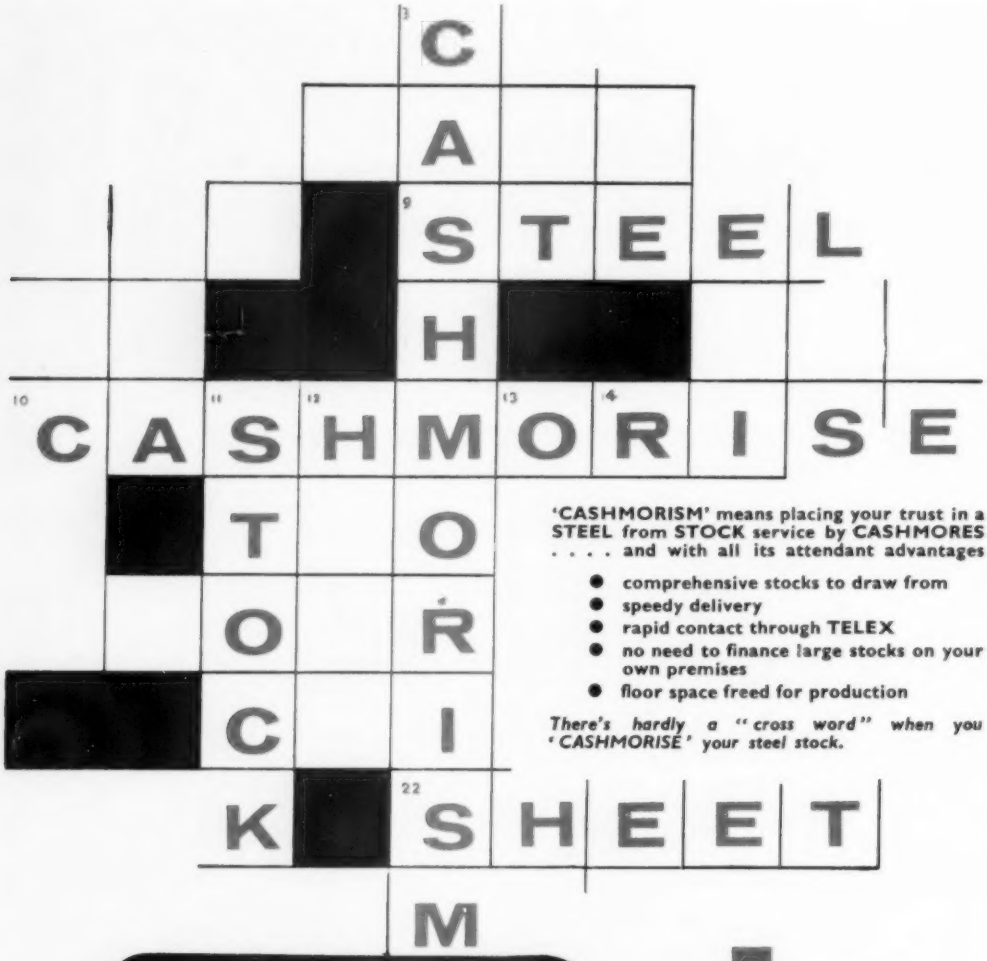
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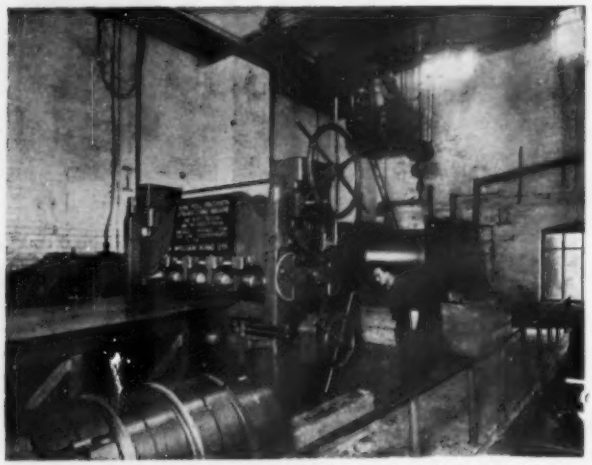
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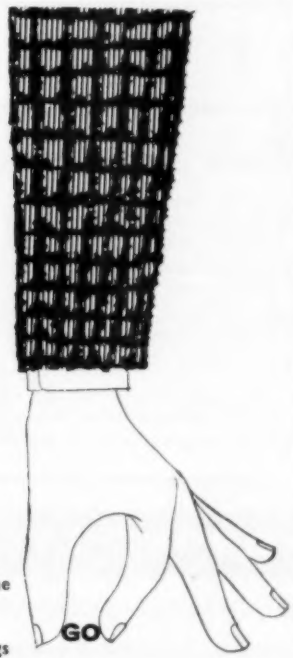
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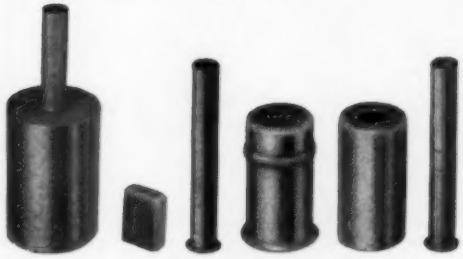
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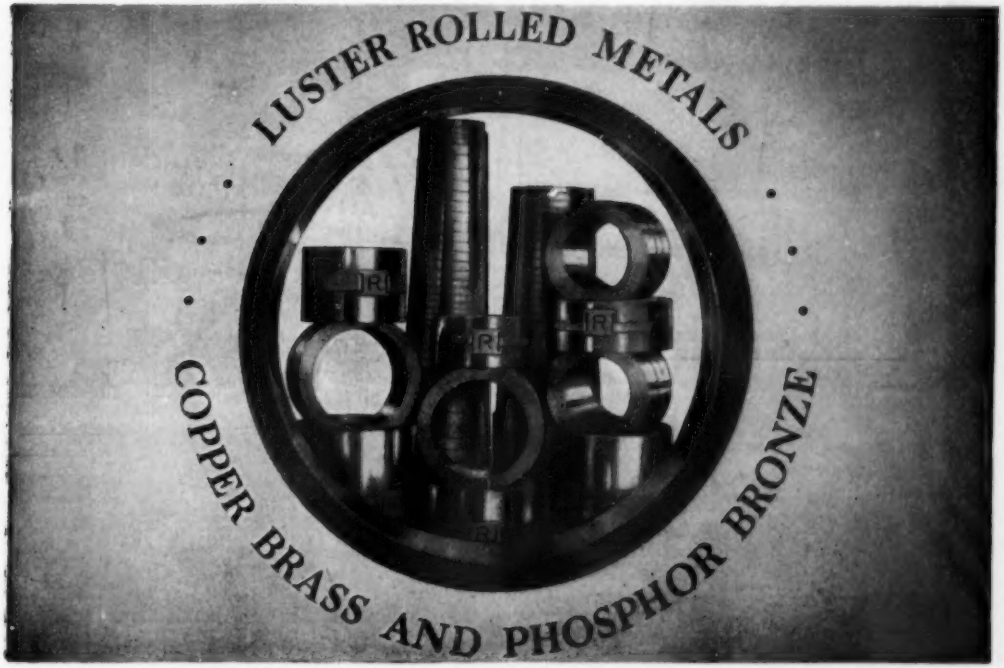
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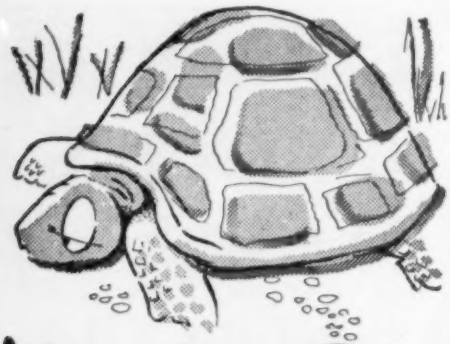
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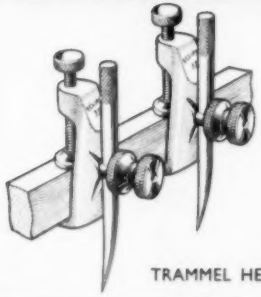
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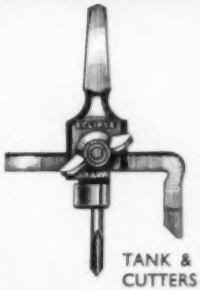
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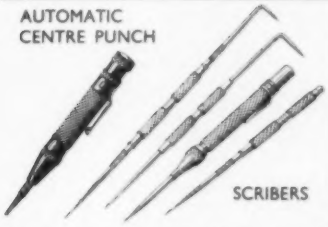
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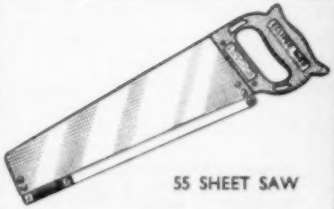
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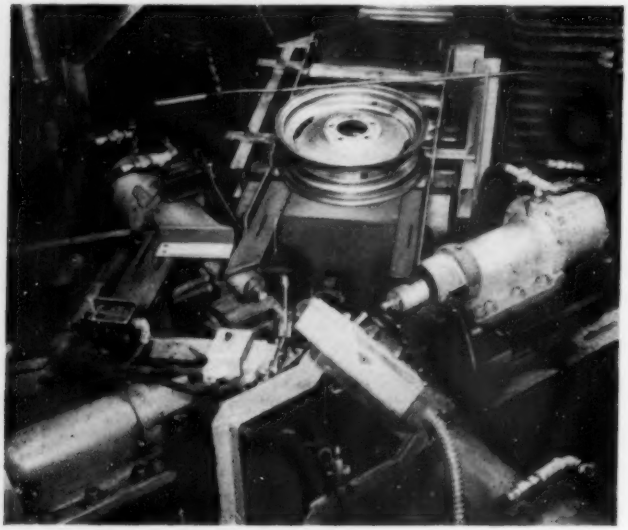
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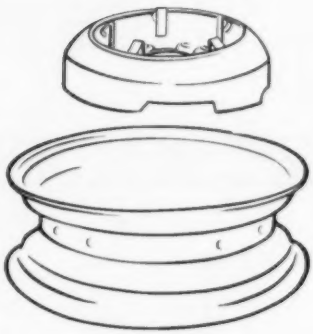
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Only the Sciaky Patent Three-Phase balanced load system of Resistance Welding can produce welds with the consistency, quality and strength demanded by the modern highly stressed automobile wheel. Wherever quality and strength are vital considerations, where even lives are at stake, Sciaky Patent Three-Phase is the only answer. Three-Phase costs you less to install and operate too! – gives a power factor of 85% or better and permits four times as many welders to be used on the same power line as an equivalent A.C. welder. Three-Phase provides for complex electronic programming for "difficult" materials and completely eliminates costly current compensator devices.

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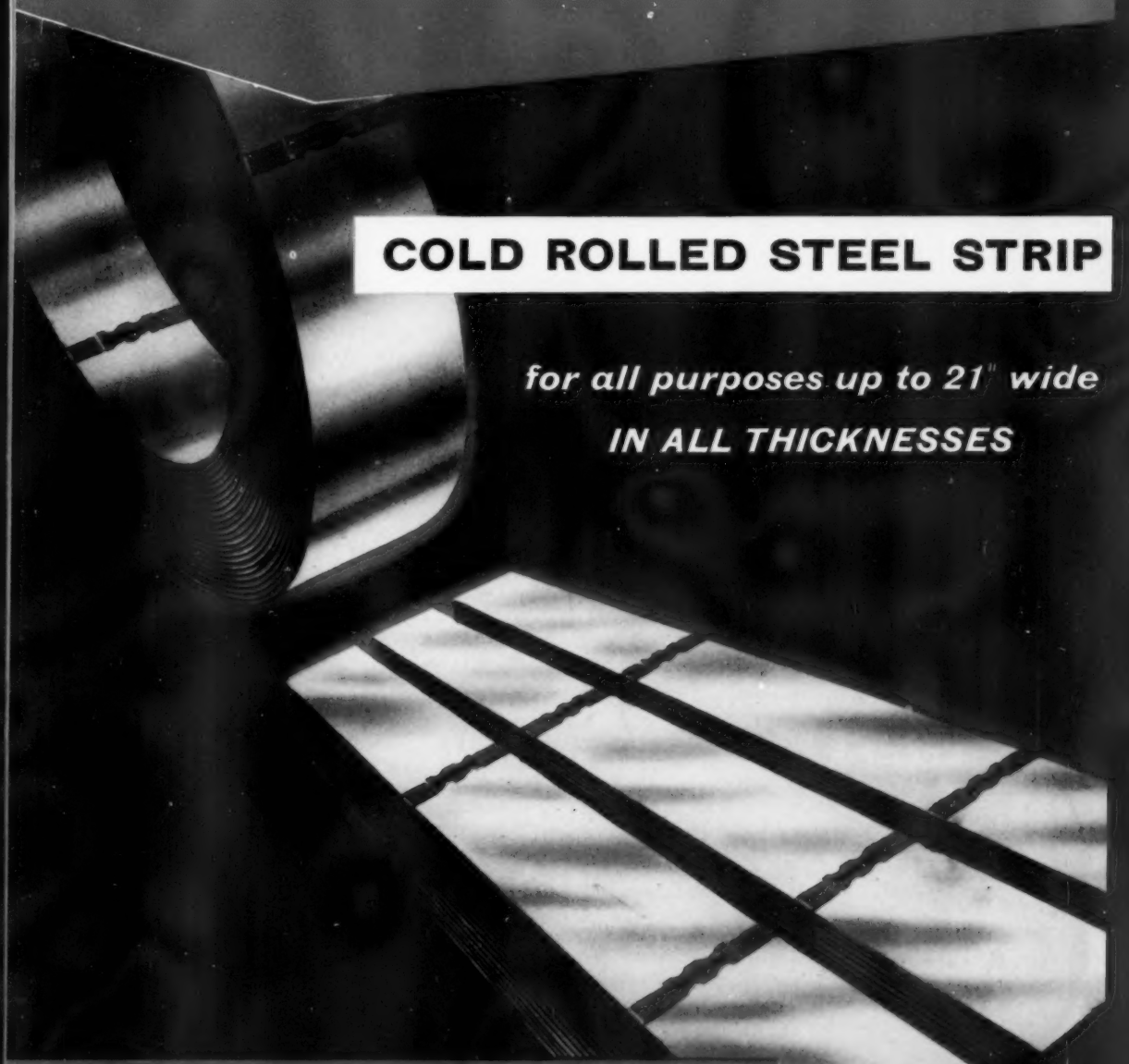


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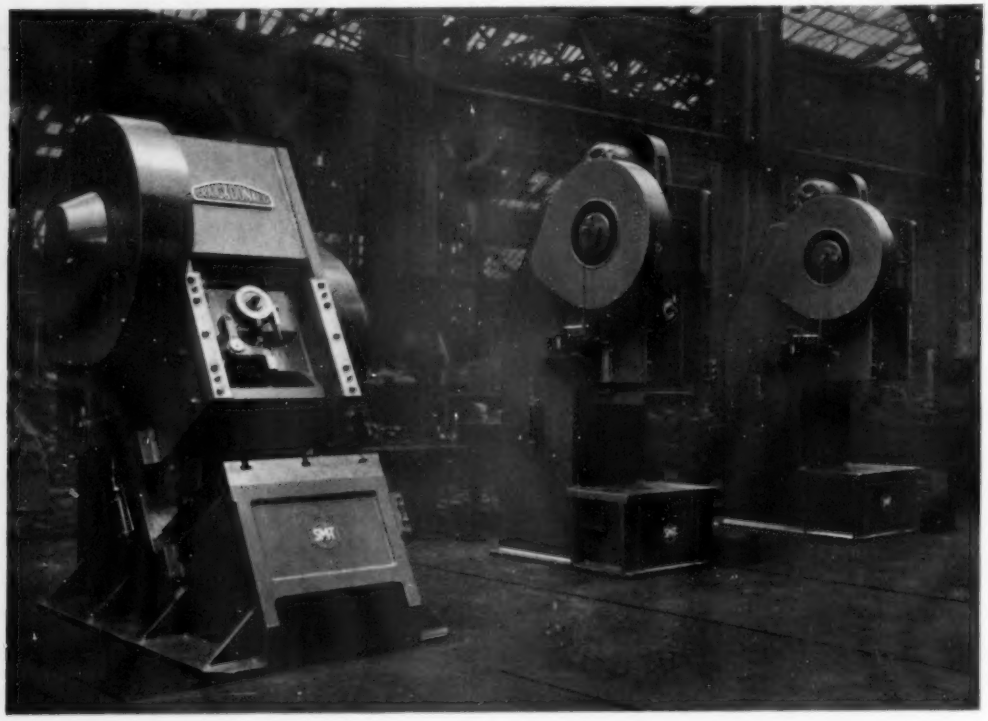
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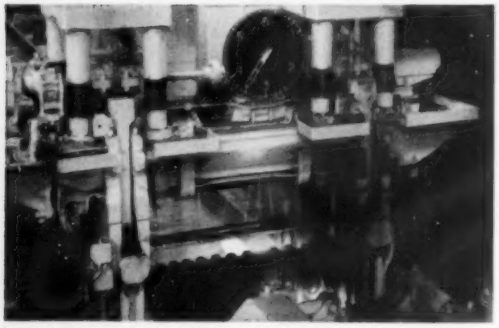
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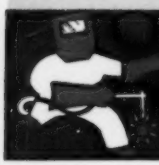
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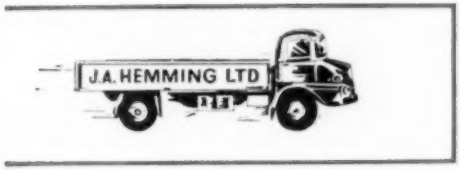
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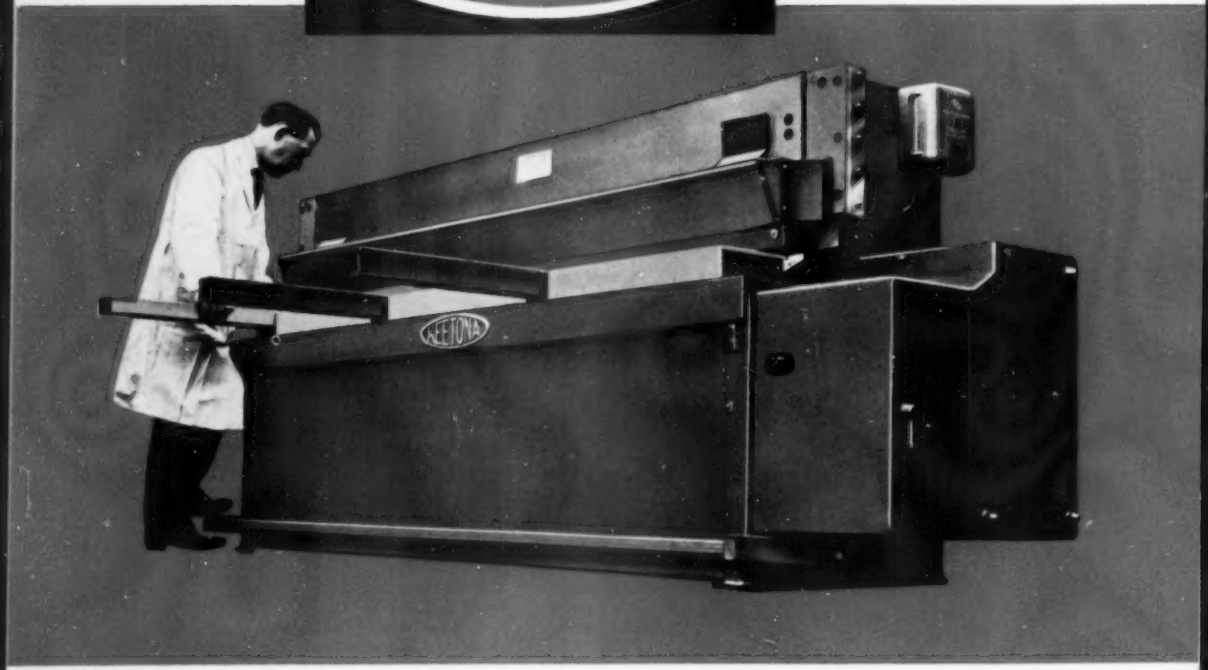
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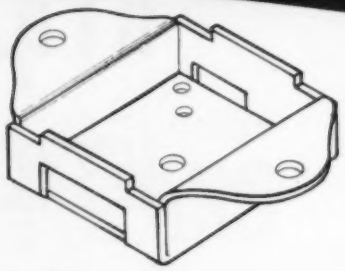
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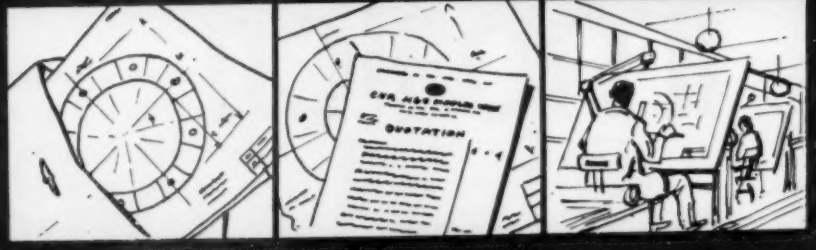
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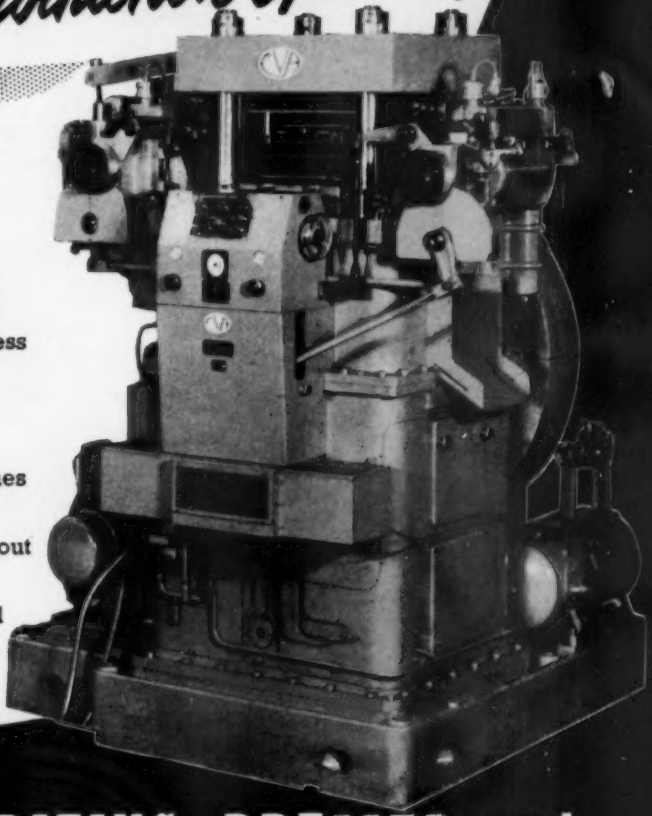
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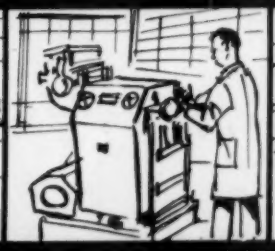
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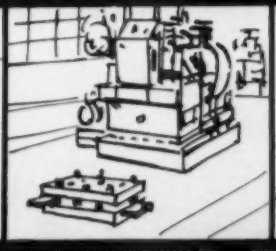
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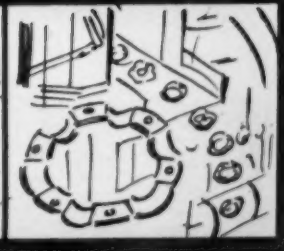
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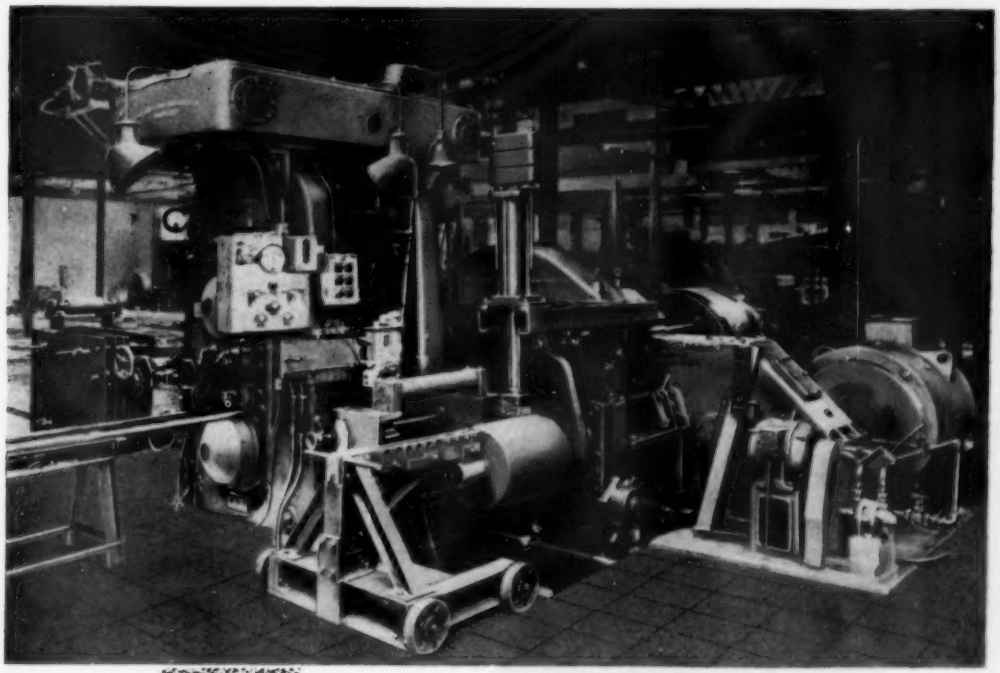
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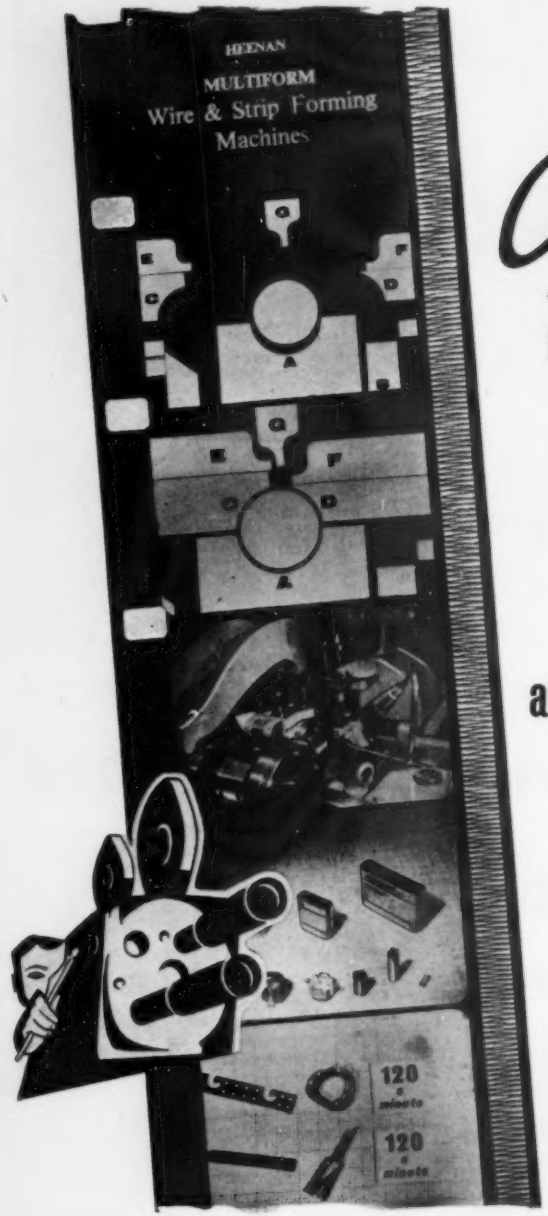
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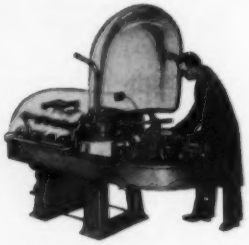
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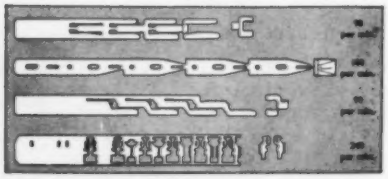
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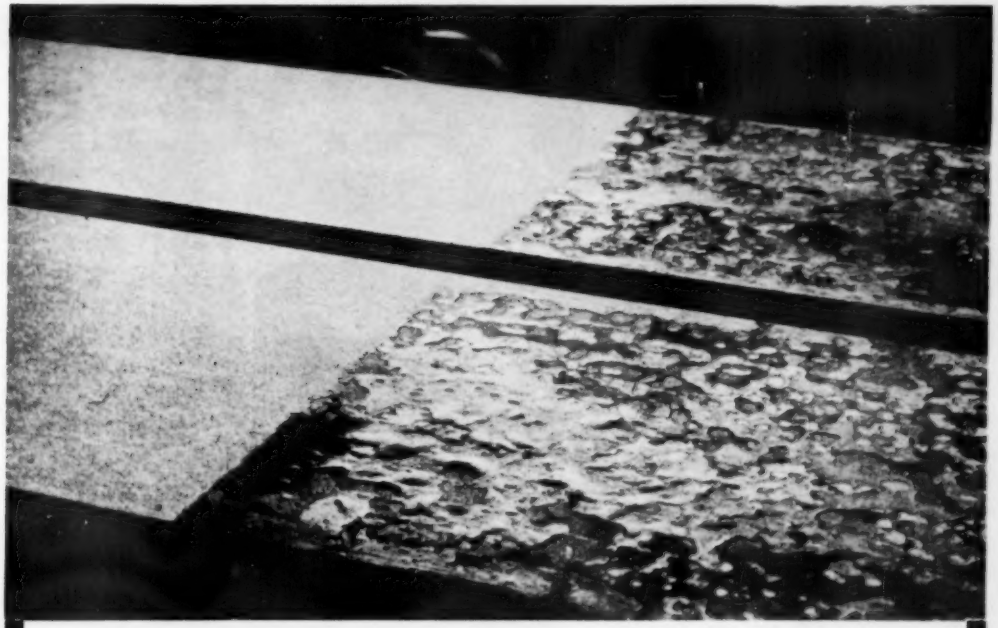




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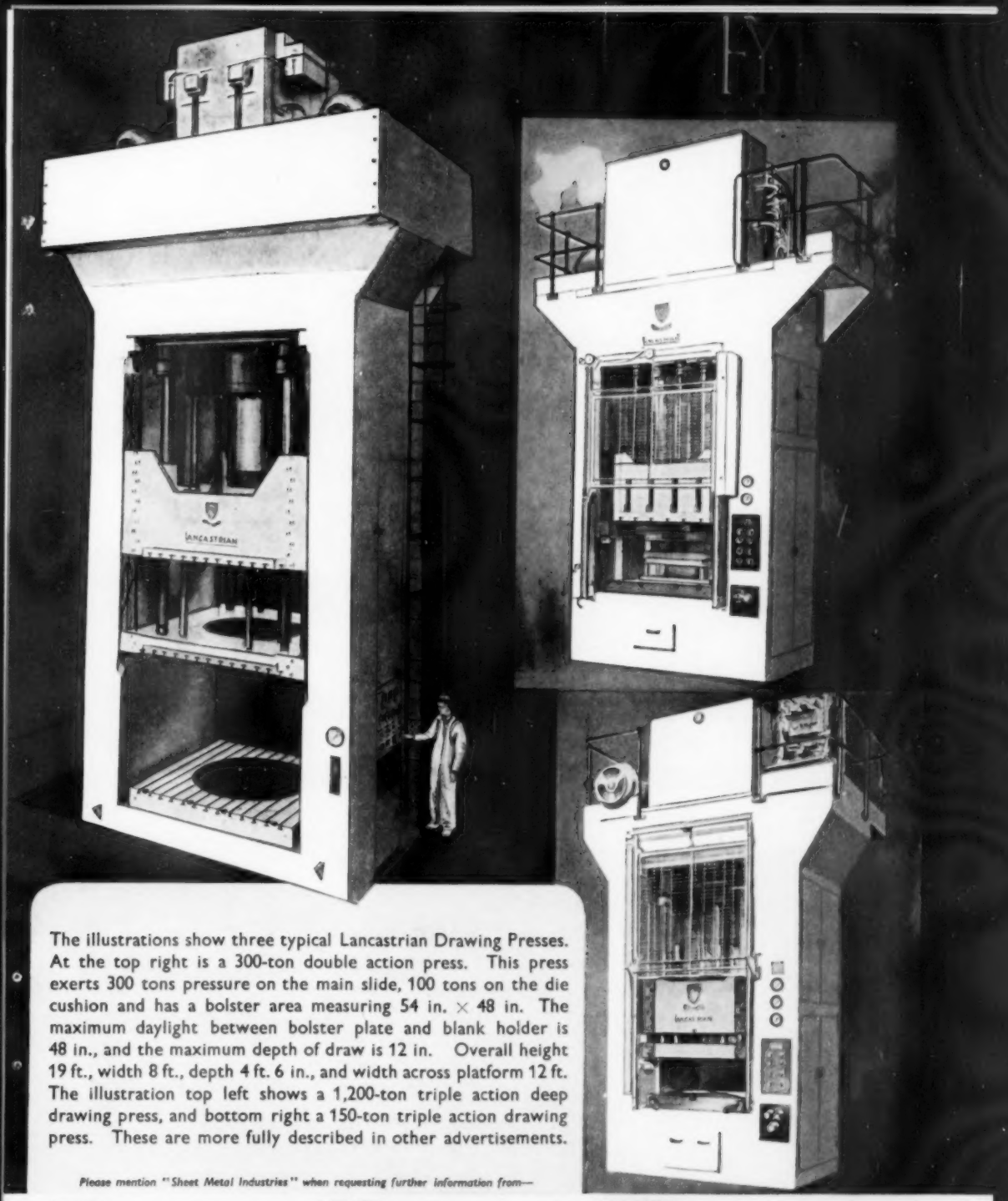
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The illustrations show three typical Lancastrian Drawing Presses. At the top right is a 300-ton double action press. This press exerts 300 tons pressure on the main slide, 100 tons on the die cushion and has a bolster area measuring 54 in. × 48 in. The maximum daylight between bolster plate and blank holder is 48 in., and the maximum depth of draw is 12 in. Overall height 19 ft., width 8 ft., depth 4 ft. 6 in., and width across platform 12 ft. The illustration top left shows a 1,200-ton triple action deep drawing press, and bottom right a 150-ton triple action drawing press. These are more fully described in other advertisements.

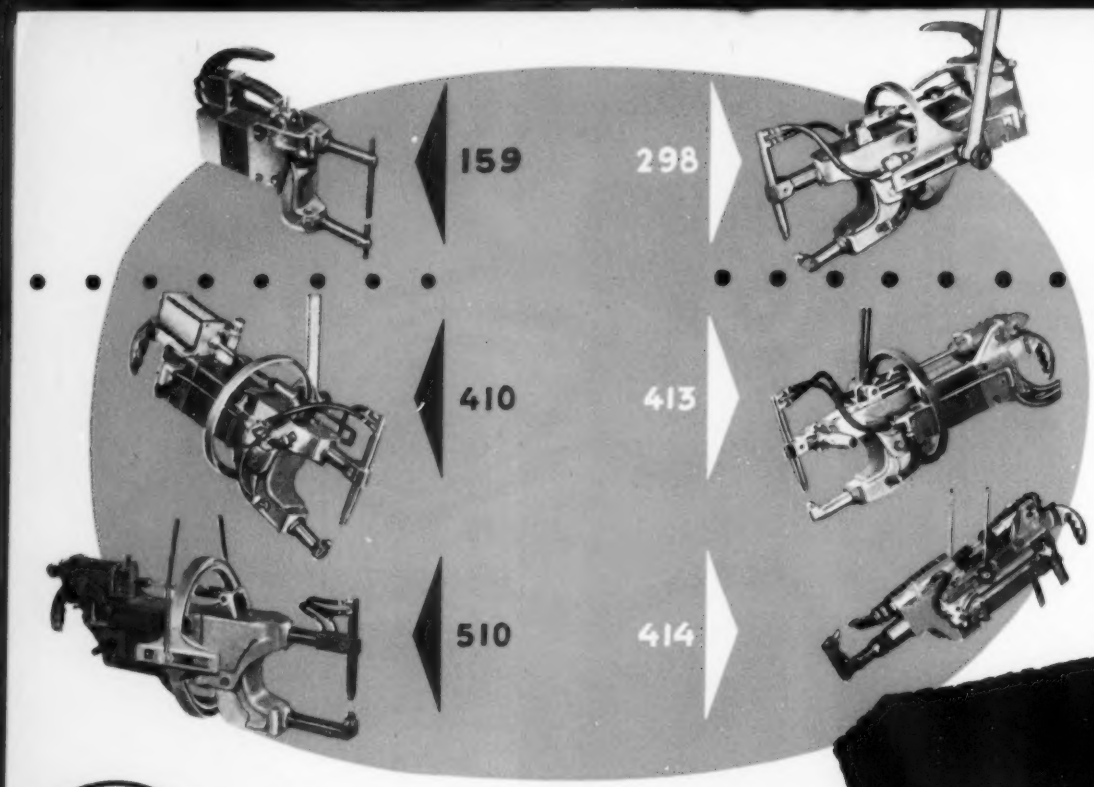
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CORRONEL* 210 *corrosion-resisting alloy*	CORRONEX* B
CORRONEL* 220 *corrosion-resisting alloy*	CORRONEX* B
INCONEL* *oxidation-resisting alloy*	'132' INCONEL
INCOLOY* *heat-resisting alloy*	INCO-WELD 'A'

MATERIAL		METAL-ARC ELECTRODE
INCOLOY* D5		INCO-WELD 'A'
NIMONIC* 75	*heat-resisting alloys*	NICREX* 4 or CHROMAC* B
NIMONIC* 80A		
NIMONIC* 90		
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BRIGHTRAY* C		NICREX* 4 or CHROMAC* N
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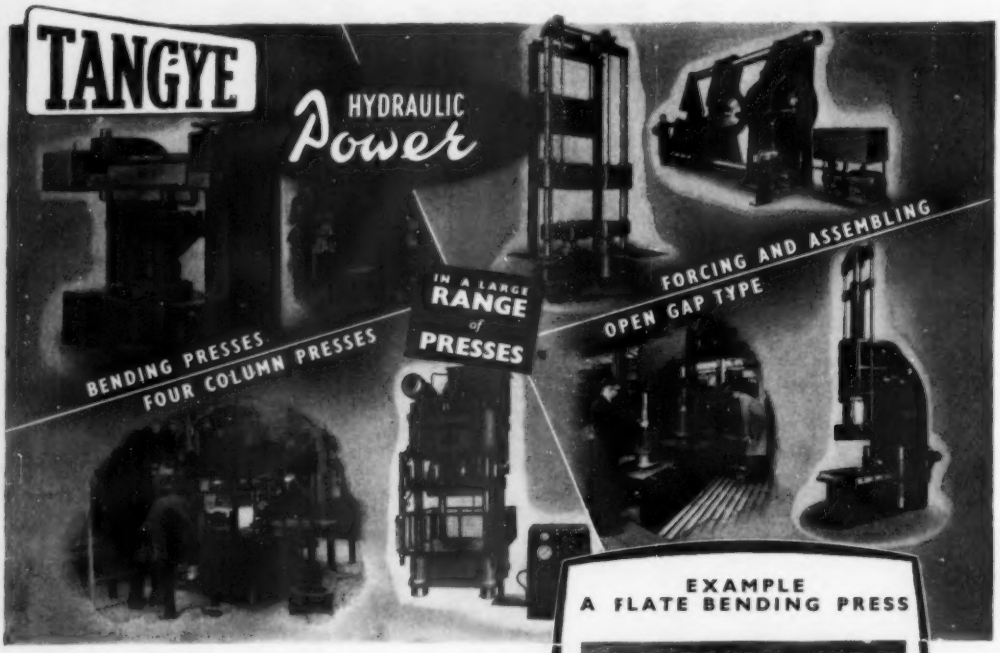
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We have available a 16-mm sound film in colour entitled '*Welding of Wiggin High-Nickel Alloys*' which is available without charge for showing to engineering societies, training classes, etc.

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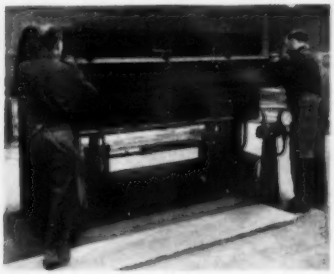


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This example has a 3" daylight and tools and a 6" stroke. It is operated by a high-speed pump.

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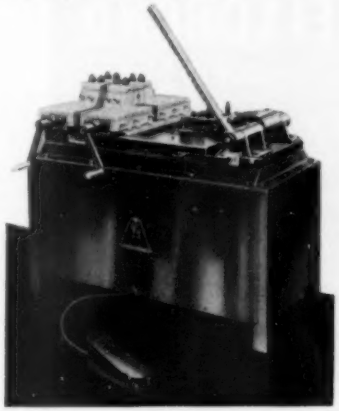
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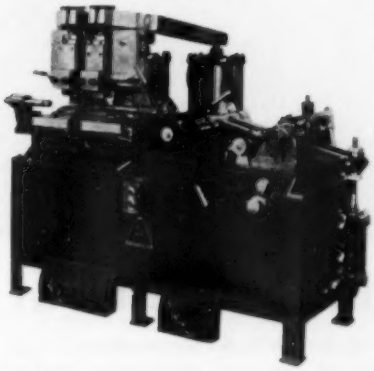
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ABOVE

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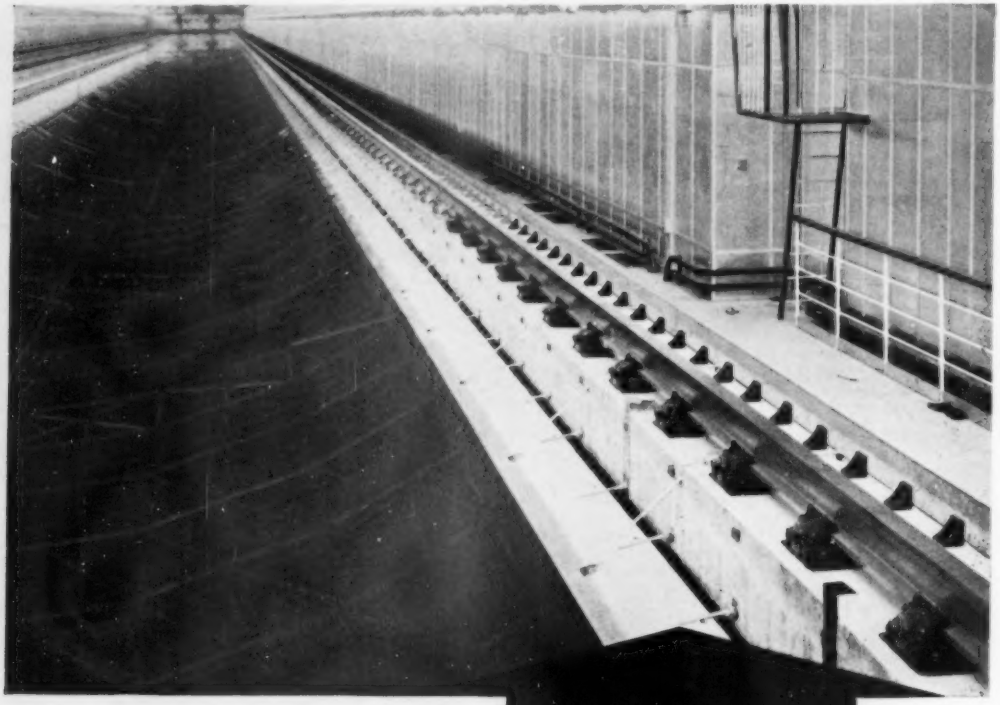
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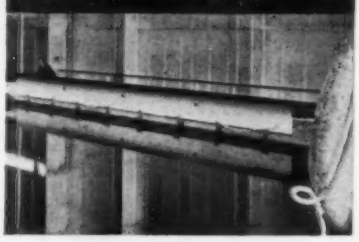
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BK 24	1200	140	—
BK 24A	1200	140	Integral
BK 24B	1200	140	Clamp on
BK 34	2400	355	—
BK 34A	2400	355	Integral
BK 34B	2400	355	Clamp on
BK 42	600	56	—
BK 42A	600	56	Integral
BK 42B	600	56	Clamp on
BK 66	300	22·4	—

* Ratings are for welder control service with two valves in inverse parallel at any voltage from 250-600v. r.m.s.

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Type	Maximum peak voltage (Kilo volts)	Maximum average current at peak voltage (Amps.)
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BK 46	2·1	150
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No. 48L
Stamping Trimmer in use trimming and forming bead.

Illustration by courtesy of Apsley Metal Products Ltd., London.

THE QUICKWORK STAMPING TRIMMER

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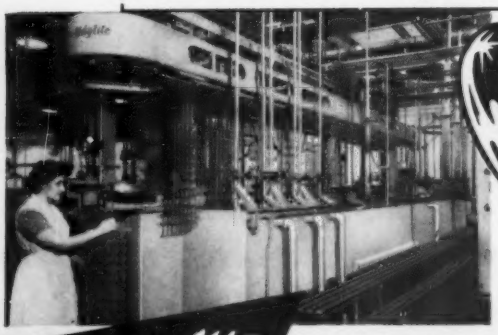
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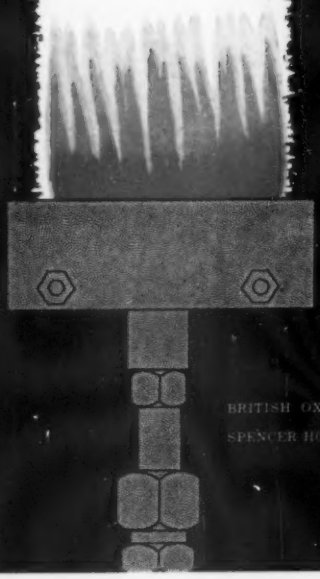
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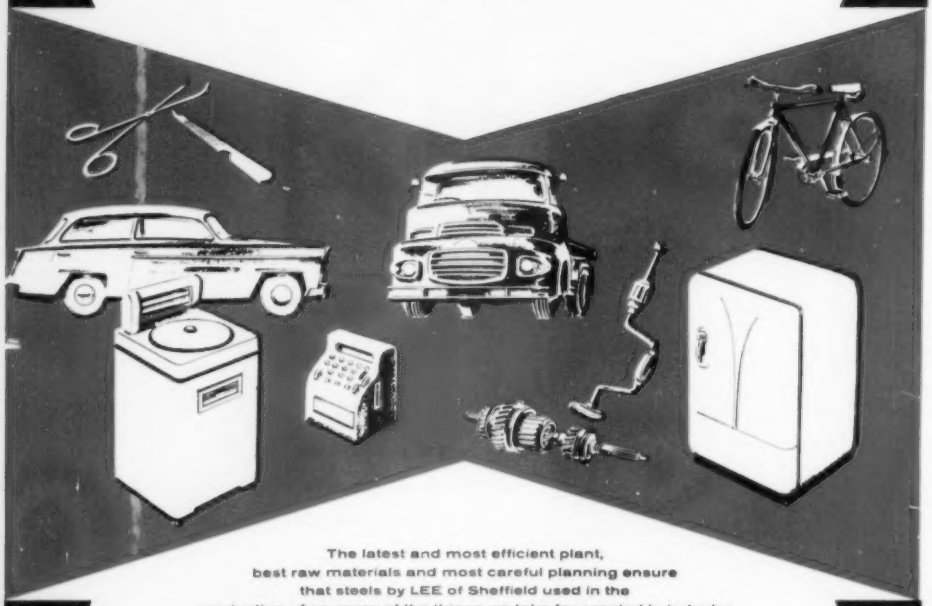
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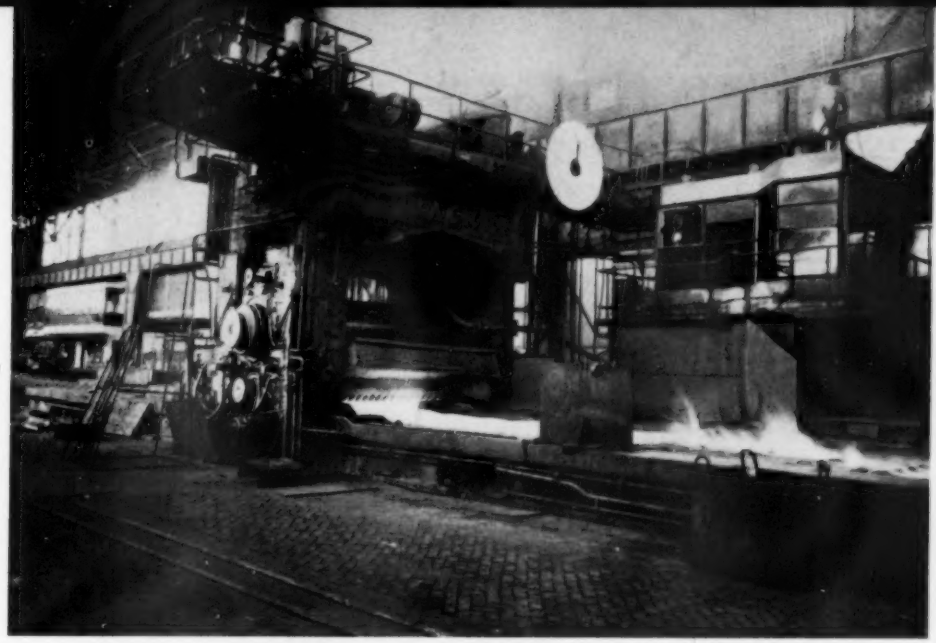
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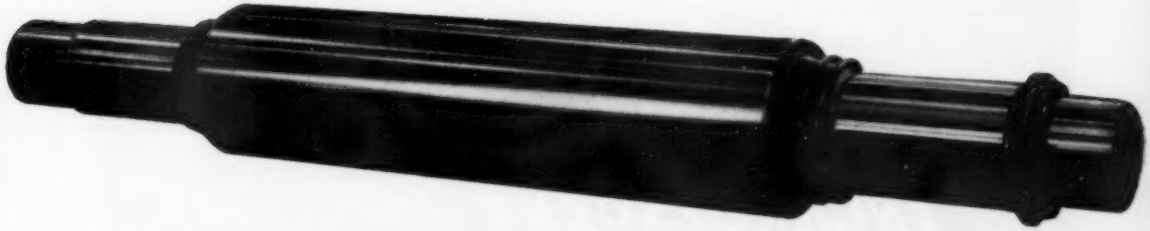


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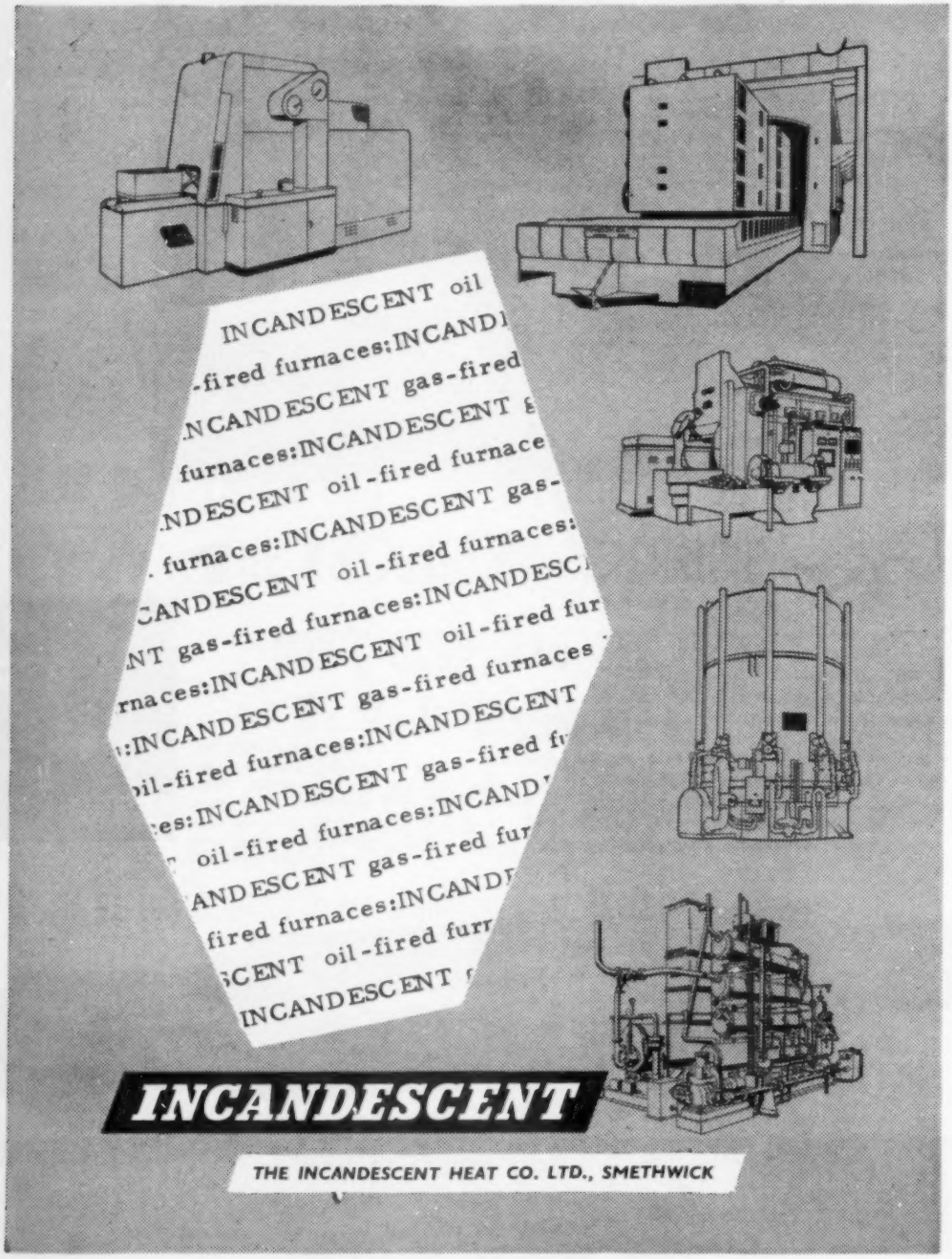
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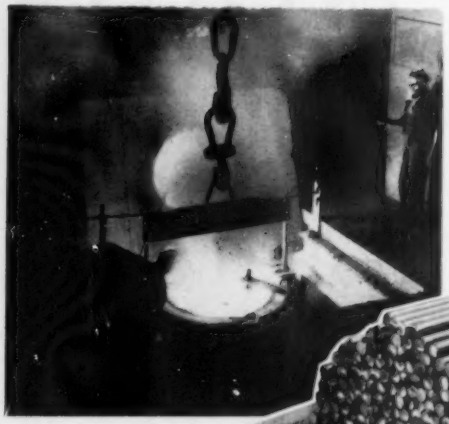
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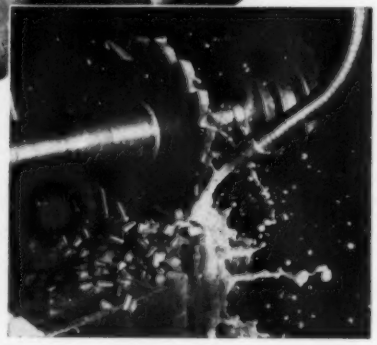
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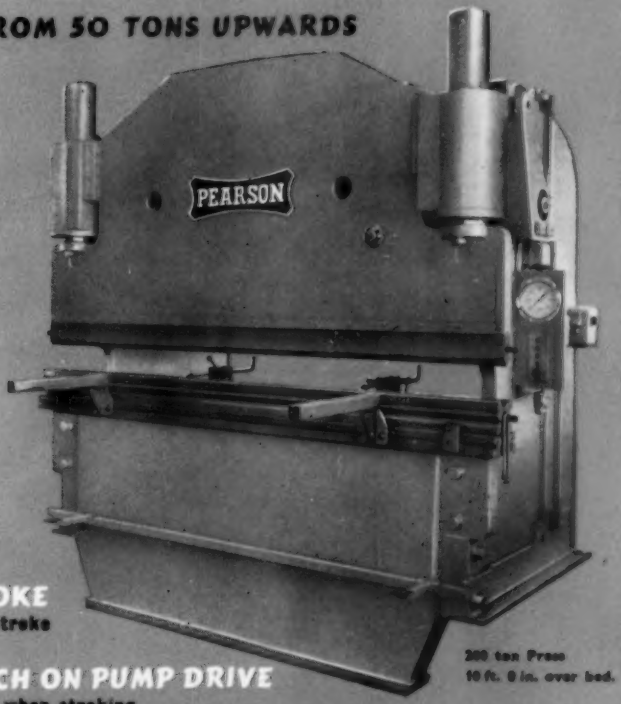
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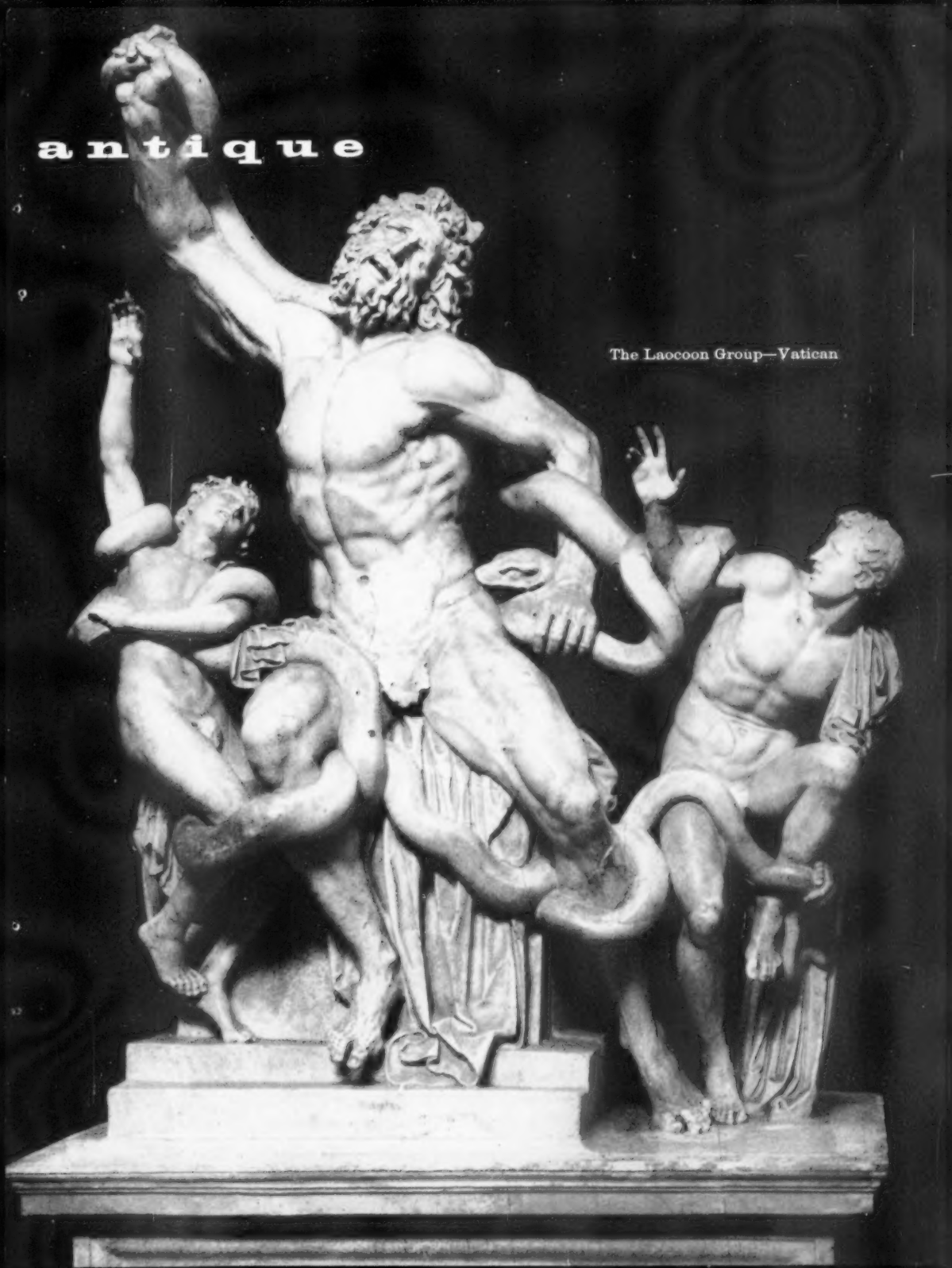
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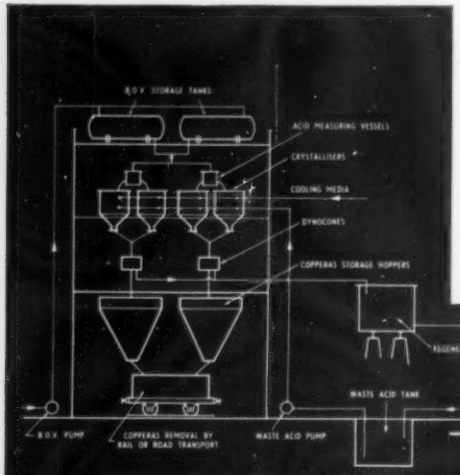
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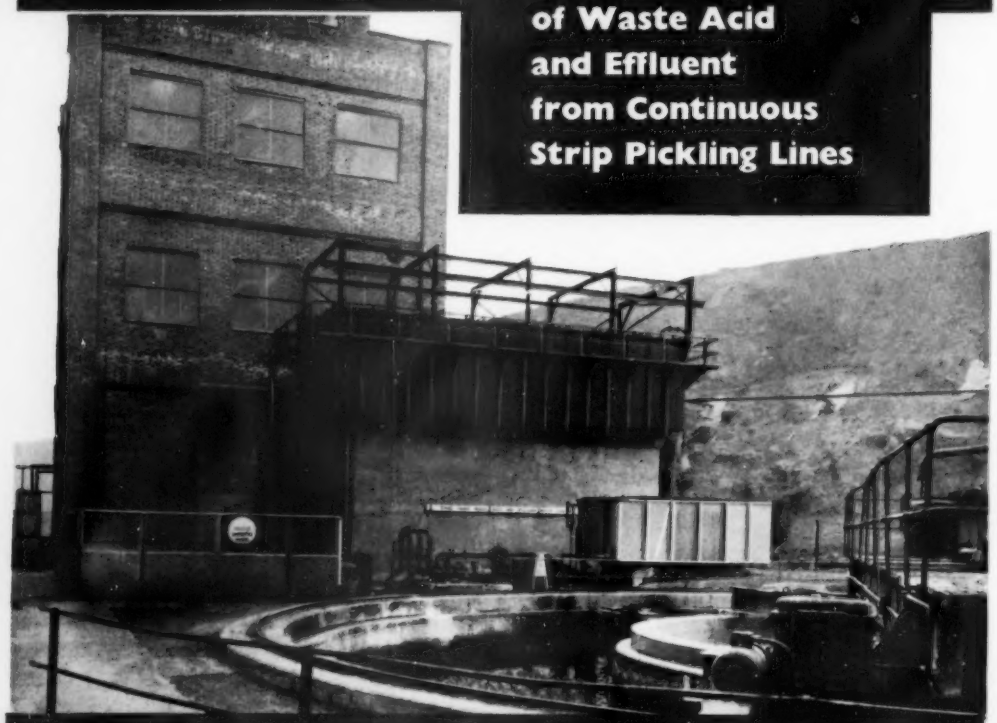
ACID RECOVERY PLANT FLOW DIAGRAM

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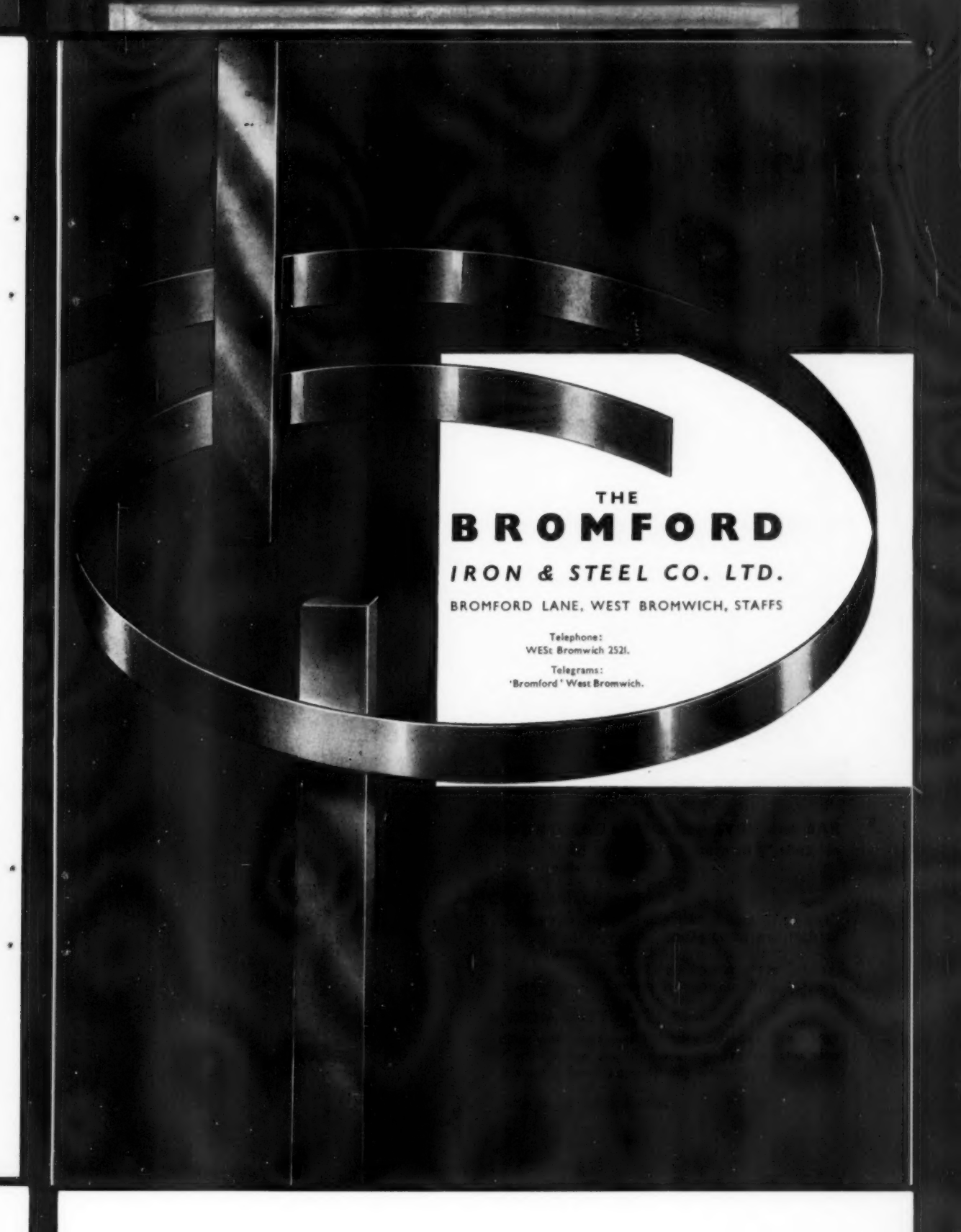
In addition to the above there is installed a large neutralisation plant for dealing with all waste effluents from the continuous strip lines. These plants are larger than any likely to be required in the wire industry, but the same principles are applicable to plants on a smaller scale and of smaller capacity, which would be of considerable interest and value to the medium and large wire mill using sulphuric acid.

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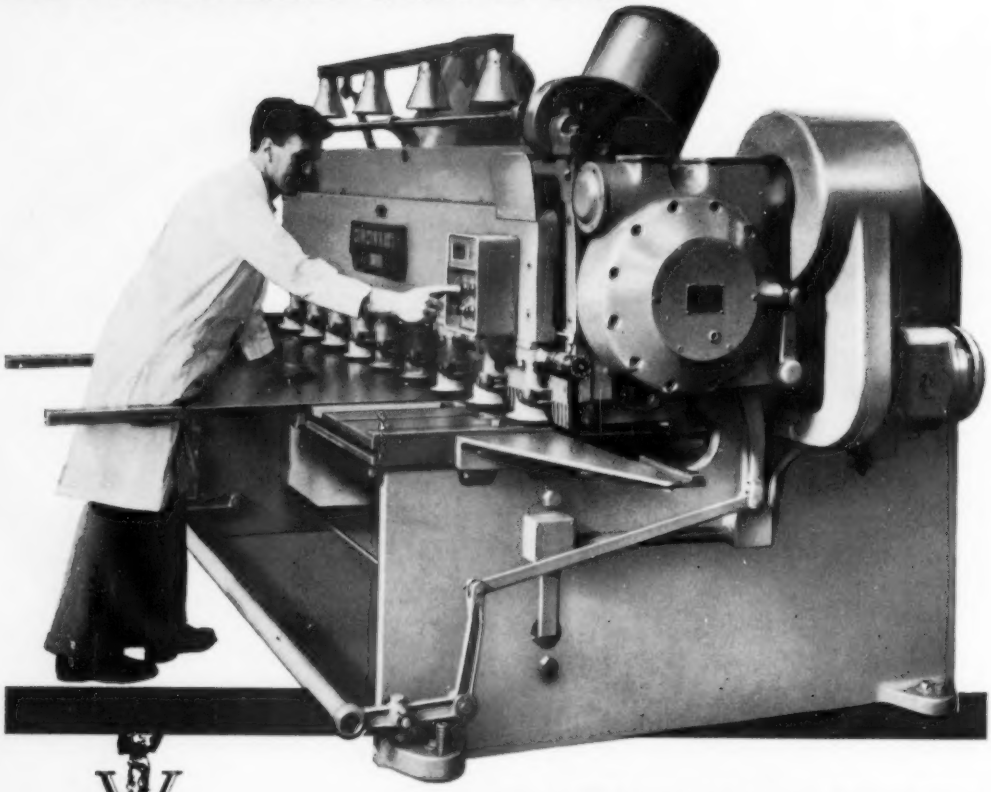
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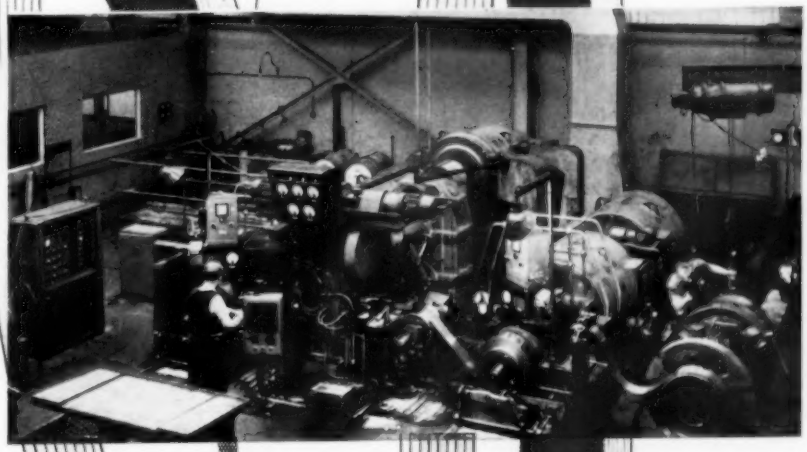
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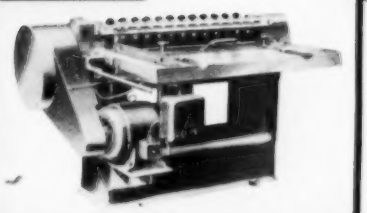
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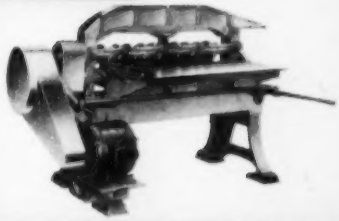
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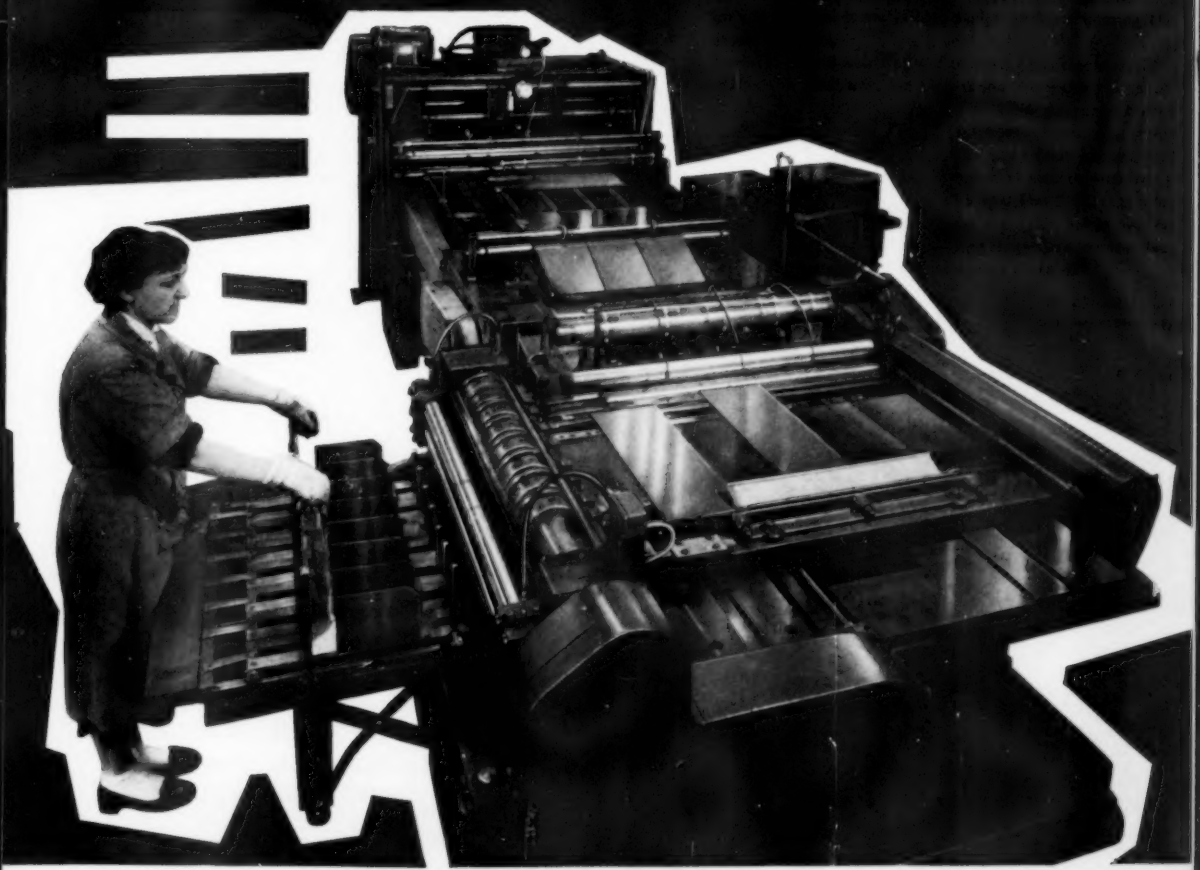
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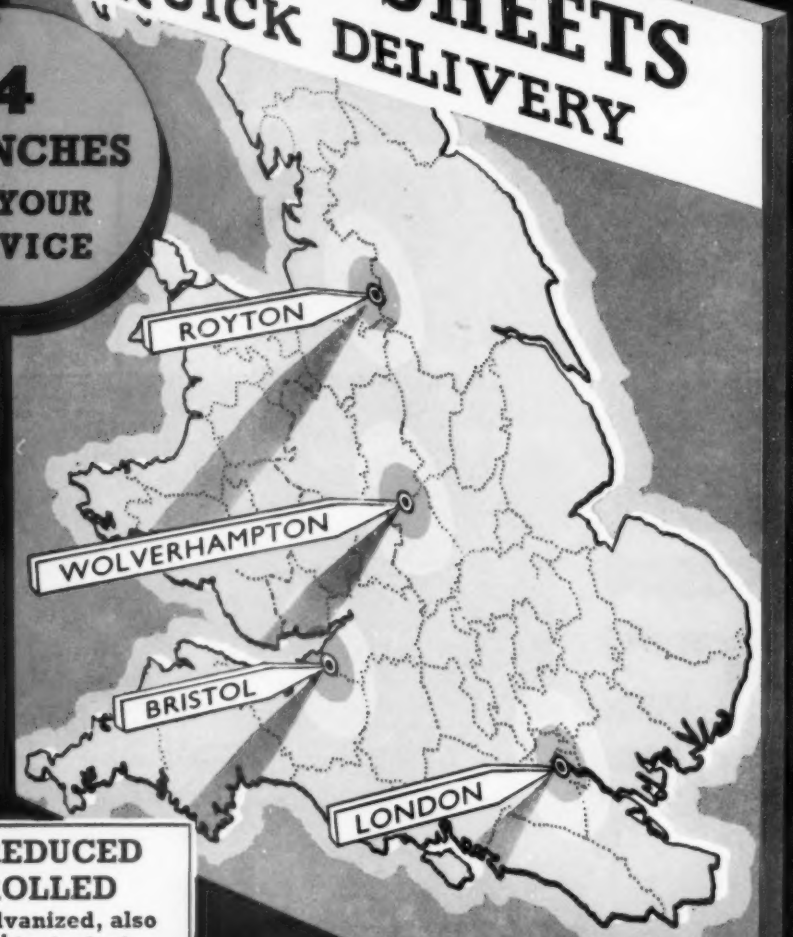


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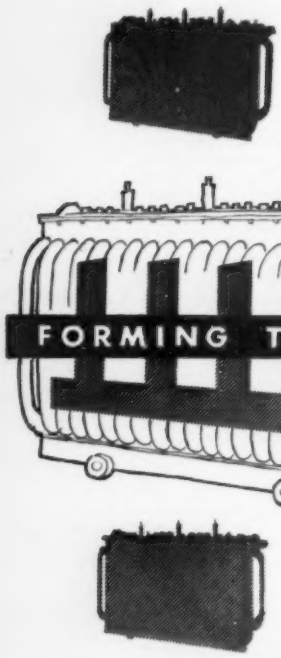
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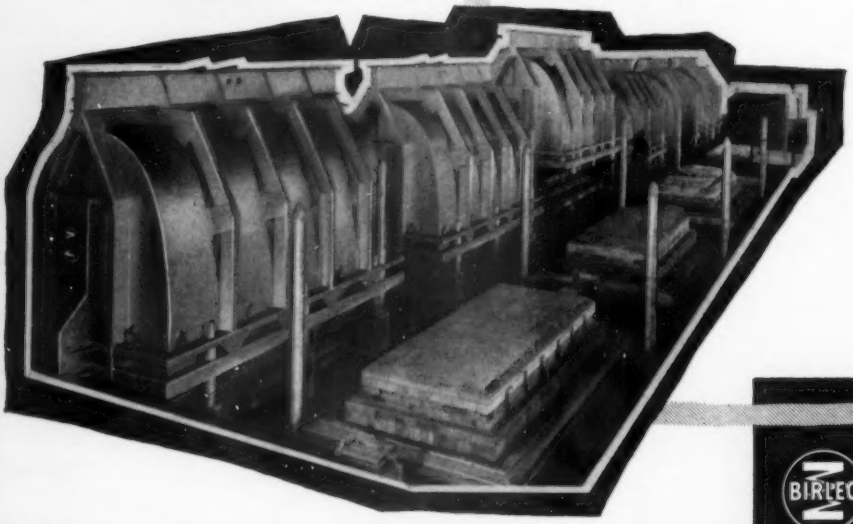
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PARIS IN THE SPRING

THOSE delightful attributes which have so justly earned for Paris its reputation as the gay city were very much in evidence during the last week in May this year and provided a charming setting to an event of some significance. For it was in Paris, on May 23 last, that the first full-scale technical meeting of the International Deep Drawing Research Group began.

This International Group was conceived in 1957 at an informal meeting of experts in the field of the deep drawing of sheet metal, representative of a small number of European countries. At this meeting it was agreed to initiate a measure of collaboration in research into deep-drawing problems, with the major emphasis laid initially on investigations into the suitability of the cupping test, devised by Professor H. W. Swift, as a means of assessing the suitability of sheet metal for deep drawing. Since this original meeting a number of other countries have expressed interest in the aims of the Group and have commenced participation in its joint investigational work. The Paris meeting was convened primarily in order to discuss progress, and to determine whether any extension of the field of activity of the Group should be contemplated.

It was however decided that such a meeting provided an excellent opportunity for the discussion of sheet-metal-forming topics on a broader platform, and in consequence, the International Deep Drawing Research Group collaborated with the Société Française de Métallurgie in staging a three-day Colloquium on " Sheet Metal Forming and Methods of Testing." This Colloquium was attended by over 250 delegates representing 15 nations and, in all, over 30 papers were presented and discussed. It is hoped to publish in subsequent issues of this Journal a substantial proportion of these.

At the I.D.D.R.G. administrative meeting, which was held after the Colloquium, eight nations were represented and took the initial steps towards giving the Group a more formal constitution. The British delegation at this meeting was led by Dr. J. G. Wistreich (Head of the Mechanical Working Division of B.I.S.R.A in his capacity as Chairman of the British Deep Drawing Research Group of the Institute of Sheet Metal Engineering, which is the British member body of the International Group. Agreement was reached at this meeting for a limited extension of the immediate investigational programme of the I.D.D.R.G.

The aims of this International Group as at present envisaged have met with considerable and enthusiastic support from nations inside and outside Europe, and this support can be expected to grow in the near future. It is also abundantly clear that organized research into problems attendant upon the usage of sheet metal features much more prominently in the research programmes of overseas countries than would appear to be the case in the U.K.

The potentialities of sheet metals as materials of construction are still very far indeed from being fully exploited and a much greater effort in organized research and investigation is called for than is evident at the present time.

The SENDZIMIR PLANETARY

Principles of Operation and Theory of Rolling

By R. TOVINI

THE hot-rolling of flat products is a fairly old form of metal working. Its invention is generally attributed to Leonardo da Vinci, since he left behind him the first sketch of a rolling mill which has survived up to the present day.

From those far-distant times up to about 30 years ago, methods of rolling remained substantially unchanged and improvements consisted in increasing the dimensions of the mills and the force applied and in mechanizing all the operations which could not conveniently be performed manually. Throughout this period, sheets and plates were reduced in thickness by passing them repeatedly through the same pair of rolls, the gap between which was progressively reduced after each pass, until the desired thickness was obtained. This method of rolling is still widely used even today for other than mass production, although the lengths which can be handled are restricted and one or more intermediate reheats are necessary to obtain high reduction, since temperatures fall appreciably owing to the duration of the operation. In addition, as in all intermittent processes, special precautions have to be taken if a uniform and high-grade product is to be achieved.

The continuous rolling mill has eliminated all these limitations, by the use of a succession of roll passes of gradually decreasing thickness, so that the reduction from the initial to the final thickness is effected so quickly that the material cannot cool off sufficiently.

Naturally the workpiece, once its front end is fed into the last pass, remains gripped by the whole series until its tail leaves the first pass. It is thus apparent that it is necessary to regulate the speed of each pair of rolls accurately between one pass and the next so that a constant volume of material passes through in unit time.

This requirement calls for a somewhat sensitive speed control, particularly at the high speeds used in practice, and explains why a solution which appears so simple and intuitive and which clearly offers widespread economic and technological advantages has had to wait for introduction until sufficient progress has been made in the field of electrical speed-control gear.

It will be apparent that in the continuous rolling mill there can be no question of any intermediate reheating and that, therefore, the rate of cooling of the strip in passing through the successive roll stands imposes a fixed minimum value on the exit speed at the last stand, and if this is not attained, final deformation will take place below the critical temperature.

This exit speed will be the greater, the smaller the final thickness and the greater the distance between two successive stands, or the diameter of the rolls, or the width of the strip.

Apart from considering the problems to be solved at these high speeds, it should be emphasized at this point that a continuous rolling mill is obliged to operate at high speeds and, therefore, must have a high hourly output. In addition, as a consequence both of the sensitive control required, and of the quantities of heat involved, a considerable time is required to recover the optimum working conditions after each stoppage of the mill as well as after any change in the rolling specification, which reduces the flexibility of the continuous rolling mill and thus makes it principally suitable for mass production. Furthermore, the high investment capital required for a unit comprising many roll stands with electrical controls so complicated as to constitute a substantial proportion of the total cost, makes it necessary to obtain very high outputs to reduce the depreciation costs.

ROLLING MILL . . .

AFTER a brief descriptive outline of the action of the mill, there follows an analysis of the elementary principles of the plastic deformation of a slab in the rolls.

From this a series of mathematical expressions is derived correlating displacements, strains, velocities, stresses, torques and power.

It is shown how application of the elementary theory thus developed can enable the necessary calculations to be made for ensuring the proper working of the mill and the correct dimensioning of its components, as well as helping the explanation of some particular aspects of this method of rolling, such as the question of vibration, the surface corrugation of the strip, the backthrust and its reversal and how to make suitable quantitative allowances for these factors.

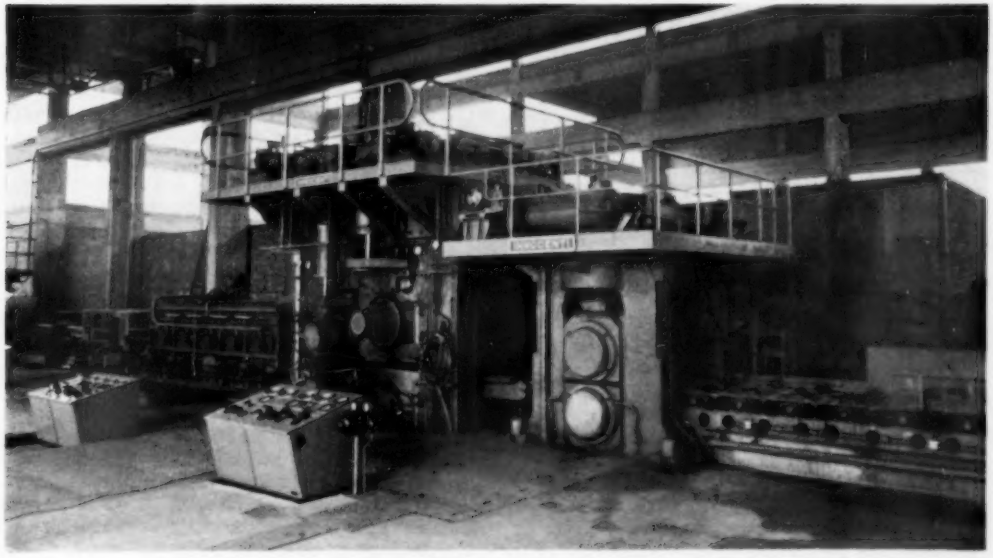
The method enables a closer investigation to be made of the technical process and should be of use both to design engineers and to mill operators.

The planetary rolling mill originated in an idea even simpler than that of the continuous rolling mill. The sequence of passes designed to obtain the final cross-section is obtained in this case by working on a fairly restricted area of the material, and thus in a time short enough not to permit any appreciable loss of heat in it. In fact, it is observed that during the rolling process the temperature of the work-piece is increased as a result of the contribution made by the work of deformation.

Thus, two basic advantages are obtained, that of being able to effect the deformation in a very short space of time, *i.e.*, in a single machine, and that of permitting a low minimum speed and hence a low minimum hourly tonnage. In addition, no control problems arise as there is no set of machines which must be made to synchronize and maximum flexibility is possible as regards the production of small quantities to different specifications.

Furthermore, it will at once be realized that the

Fig. 1 (a).—General view of planetary hot-rolling mill of SAFIM, S.p.A., Milan. Control stands in the foreground. In the background, from the left are the holding furnace, the rolling mill and feed rolls, the looper roll, the two-high planishing mill and the run-out roll table



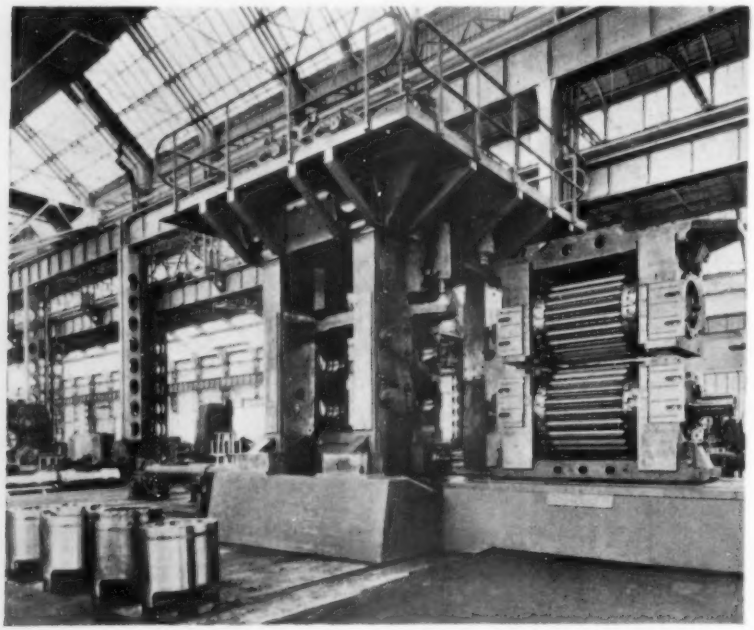


Fig. 1 (b).—General view of mill stand with planetary rolls removed

cost of a rolling mill of this type, consisting of a single stand, even though of fairly complex construction, will only be a fraction of the cost of a continuous mill, normally consisting of 12 roughing and finishing stands.

The planetary rolling mill appears, therefore, to offer considerable interest to undertakings of medium size, rolling a comparatively small but highly varied tonnage, and for whom the investment involved in the acquisition of a continuous mill would neither be possible nor by any means reasonable.

At present there are four planetary rolling mills operating on an industrial scale in the Western hemisphere, two of which are in Great Britain, one in Canada, and one in Italy. All work on the Sendzimir principle. It has also been reported that, recently, a planetary rolling mill has been brought into operation in Russia.

Italy has the largest mill constructed up to the present, this being capable of rolling strip up to a width of one metre (39 in.).

Articles have already appeared in British and American journals on installations already constructed, although the first of these has operated on an industrial scale only for a little over five years. The structural features have been illustrated and many of the characteristic working features and the technological results obtained.

As yet, however, no detailed study of the rolling process has been made, starting from an elementary analysis, and proceeding to the formulation of the general laws governing it, which may facilitate the interpretation of the practical results already obtained and to forecast those which may be attainable in the future.

The present author has endeavoured to deal with this problem in the hope that the theory thus formulated may be useful in eliminating the defects of which have gradually made themselves apparent in the working of the process and in arriving at the conditions for improved utilization of the method.

(*a*) Brief Description of the Mill and the Rolling Process

The planetary rolling mill consists of a pair of *backing rolls* of large diameter, around which rotate two sets of *working or planetary rolls* of small diameter (Fig. 1*c*). The latter are fixed at the two ends between large rings, termed *cages*, more or less resembling the race rings of a large roller bearing.

The material to be rolled, fed in the form of wide blooms or slabs, is reduced in thickness by the successive action of a large number of rolls passing over it, gradually compressing and elongating it, and passing it out in the form of strip.

As already explained, the novel idea in the process consists in concentrating the reduction on a fairly restricted area and accomplishing this in a fairly short time, without allowing the material to lose too much heat. The work of deformation of a single pair of rolls is here somewhat less than that of a corresponding pair in a four-high roll stand.

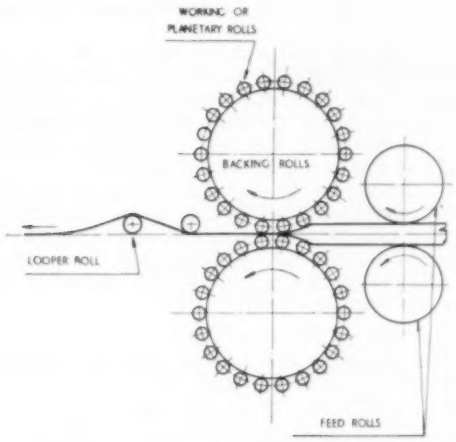


Fig. 1 (c).—Diagram of planetary roll system

The number of successive operations required to obtain a predetermined reduction of unit thickness is consequently fairly large, for which reason, the action of a planetary rolling mill can be imagined as being equal to that of a large number of four-high rolling stands.

In the case of steel, the reduction must be effected n the hot state for obvious reasons of stressing and hardening, but in the case of other materials with sufficient plasticity and resistance to hardening, there is no objection to cold-working.

The actual planetary assembly is completed by a pusher device for feeding the slab through the rolls, consisting most usually of a pair of two-high rolls which combine the pushing function with that of a sizing pass.

On the delivery side there is usually a tensioning roller, which is not indispensable but useful to improve the flatness of the sheet.

In the planetary assembly proper, the drive is generally applied to the backing rolls and transmitted to them through friction to the working rolls. There is no objection to driving the working rolls directly, through their cages or any other system for transmitting the force required for rolling, so leaving to the backing rolls the sole function of preventing springing of the working rolls.

The drawing (Fig. 2) shows four pairs of planetary rolls C_2 of a diameter d rotating around backing rolls C_1 of diameter D. These rotate loosely on their own spindles which are in turn connected radially with the cage G, the rolls being continuously pressed against the backing rolls in such manner as to obtain perfect adhesion. Their spindles may, however, be permitted a slight play in the tangential direction to enable them to move with reference to the cage during the rolling process. In rotating about the centres O_2 of the backing rolls, the planetary rolls form on the two faces of the slab, approximately cylindrical impressions of a diameter $D+2d$, obviously restricted to a short arc. This arc has an opening slightly greater than the angle of bite α_1 for reasons which will presently be apparent.

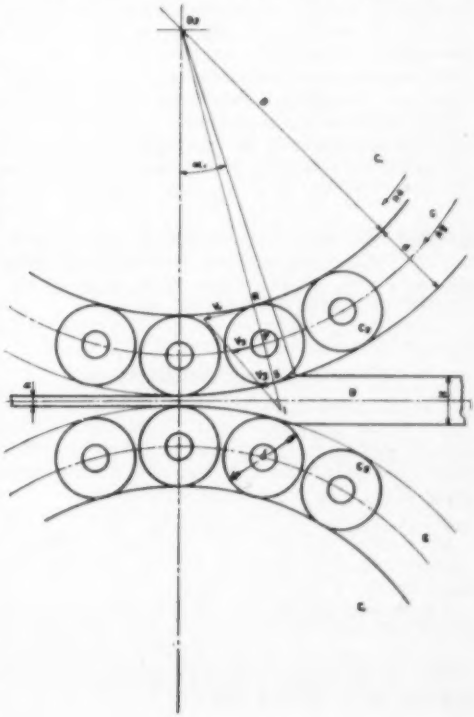
The angle of the bite which corresponds to the angle at which the surface of the slab comes into contact with the planetary roll is determined by the values of the diameters and the thicknesses as follows :—

$$\cos \alpha_1 = 1 - \frac{H-h}{D+2d} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

where H is the ingoing, and h the outgoing thickness.

The kinetic theory of the planetary assembly is based on the assumption that the contact between the planetary rolls and the backing roll on the one hand and between the planetary rolls and the slab on the other hand is such that sliding never occurs between the two surfaces. In such a case, the motion of the planetary roll is always a " rolling over," both with reference to the backing roll and

Fig. 2.—Diagram explaining operation of planetary rolls



with reference to the slab, and the instantaneous linear speed at the points of contact R and S respectively is the same for the two bodies in contact.

To produce these conditions, which are essential particularly in the case where the rolling force is transmitted by adhesion between the backing roll and the planetary roll, it is necessary for the surfaces of the rolls to be such as to ensure an optimum coefficient of adhesion.

As is clearly seen, in the conditions described, the rotational motion of the planetary rolls is strictly determined by the number of revolutions of the backing roll (n_s) and by the rate of advance of the slab (V_s), as well as, naturally, the governing dimensions of the system, *i.e.*, D and *d*.

In other words, in regard to the rotation of the cage carrying the planetary rolls, the number of rotations n_g thereof will be the same as that of the planetary rolls n_s, except for small variations during the working phase, due to the necessary play between the rolls as already explained.

This also clearly implies that any possible variations in the speed of rotation of the cage from the value predetermined by the adhesion would, if the speed of the backing roll had remained constant, indicate slipping between the planetary roll and the slab or between the planetary roll and the backing roll, setting up abnormal forces, with a consequent increase in power consumption, local overheating and possible damage to the rolls and the surface of the rolled strip.

Any variation of the cage speed from synchronous velocity is, therefore, a danger signal.

The value of the cage speed equivalent to the speed of revolution of the planetary rolls is determined by the following expression (*see* Fig. 2) :—

$$n_g = \sim \frac{n_s}{2} \cdot \frac{D + V_s/\pi n_s}{D + d} \quad \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

in which the sign $\sim$ allows for the fact that $V_s = \sim V_2$. Generally speaking, in view of the smallness of $V_s/\pi n_s$ with reference to D, then simply :

$$n_g = \frac{n_s}{2} \cdot \frac{D}{D + d} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2b)$$

(*b*) Simplifying Assumptions

The first simplifying assumptions applied are :—

(1) All the cross-sections of the slab remain truly vertical during the process of reduction ; in other words, all points in one and the same vertical plane of the slab move at the same speed ;

(2) No elastic deformation of the rolls ;

(3) Rigidity of the mill housings ; hence, a constant distance between the roll spindles, independently of the forces set up ;

(4) No slipping between the rolls and no slipping of the slab under the planetary roll at the point S ;

(5) The spindles of the planetary rolls always remain in the same vertical plane, parallel to the spindles of the backing rolls ;

(6) Constant speed of the backing rolls and cages.

In addition, it is assumed initially that : (1) the motion of the slab is discontinuous and takes place between two successive impacts of the planetary rolls, in such manner that the slab remains stationary during the whole reduction and (2) only one pair of rolls acts simultaneously on the slab.

Subsequently the case of a slab fed forward continuously, and the effect of the combined action of two adjacent rolls during a fraction of the contact period, as occurs in practice, will be considered.

The values required to be determined in the present analysis are :—

(*a*) *Kinematic Factors :*

Instantaneous motion of the strip ; instantaneous velocity of the strip ; radial draft in each position of the rolls along the arc of contact.

(*b*) *Dynamic Factors :*

Roll-separating force ; horizontal back thrust applied to the slab ; resisting torque and rolling horse-power.

PART I.—ELEMENTARY ANALYSIS

Intermittent Advance of the Slab with Only One Pair of Rolls Acting on it

Referring to Fig. 3, the roll preceding the roll shown in the diagram has, during the pass, impressed on the slab a curved reduction as shown at (1). This curved surface formed at the end of the preceding pass is in the position shown by the curve (2). Subsequently, on completion of that pass, the slab has been carried forward over a distance "*a*" by which this curve has been moved into the position shown. The curve (1), being the envelope curve of the end points of the said planetary roll, is a circular arc, the centre of which is at O_2 at the instant at which it was generated. Subsequently, as a result of the advance "*a*" of the slab and of the displacement of the said curve (1), this centre is advanced through the same distance, moving to O_1. Thus, an instant before the planetary rolls bite, the position is :—

The circular arc (1) touches the surface of the slab and has its centre at O_1 ;

O_2 represents the centre of the backing roll ;

The curve (2) which is not yet formed, represents the envelope over the planetary roll which is about to make contact with the slab and is a circular arc with a centre O_2.

This line of argument is obviously valid for both the upper and lower rolls of the same pair.

In the general case the position of a pair of rolls along the arc of contact is as shown in Fig. 3. At each instant, plastic deformation of the material only takes place in the region between the planetary rolls confined between the plane of entry and the plane of exit.

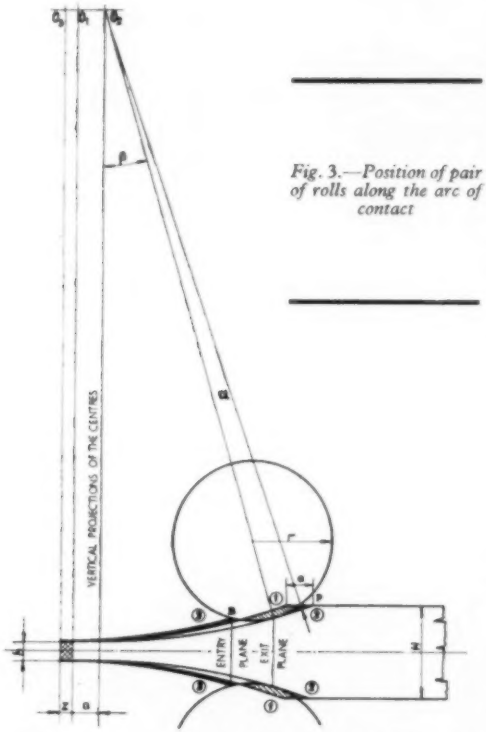


Fig. 3.—Position of pair of rolls along the arc of contact

The material on the right of the exit plane and that on the left of the entry plane is not subjected to any change of form. In addition, assuming that the advance is intermittent, the material on the right of the exit plane is stationary in space while that on the left of the entry plane advances without changing its form until the planetary rolls grip it. Therefore, during the passage of the rolls through the contact zone, the part of the front end of the slab which is on the left of the plane of entry advances in an unchanged form, as shown in Fig. 3, in which curve (3) represents the position of the front end of the slab which has advanced with reference to the centre-line O_2O_2 through a distance "$z + a$." In this expression, "z" represents the displacement corresponding to the reduction produced by the planetary rolls, while "a" represents the discontinuous advance of the slab due to the action of the driving mechanism. Obviously the displacement "z" has a value which varies with the angular position of the roll. It will be seen from Fig. 3 that this value governs not only the speed of the slab end but also the radial depth of the pass through the planetary rolls and, consequently, the force acting on the rolls and the rolling power. Hence the displacement "z" appears to be a fundamental parameter.

(1) *Instantaneous Displacement of the Strip, "z"*

The method used to find the expression for the displacement "z" is based on the fact that *the volume displaced by the planetary rolls on the right of the exit plane must be restored in front of them.* Thus, in Fig. 3, in the position of the rolls shown, the displaced volume is that lying between the curves (1) and (2) on the right of the rolls (hatched area). The disappearance of this volume corresponds to the advance of curve (1) into the position (3). Hence the volume which is cross-hatched on the left of the rolls must be equal to the volume which has disappeared on their right. Writing the expressions for the areas corresponding to the said volumes and equating them, the displacement "z" is obtained.

Two factors somewhat complicate the direct determination of "z." These are :—

(1) That the thickness of the slab in the plane of entry varies not only with angle β but also with "z"; thus in the expression for the hatched area to the left of the rolls there are two unknown variables, producing equations which can only be solved by trial and error ;

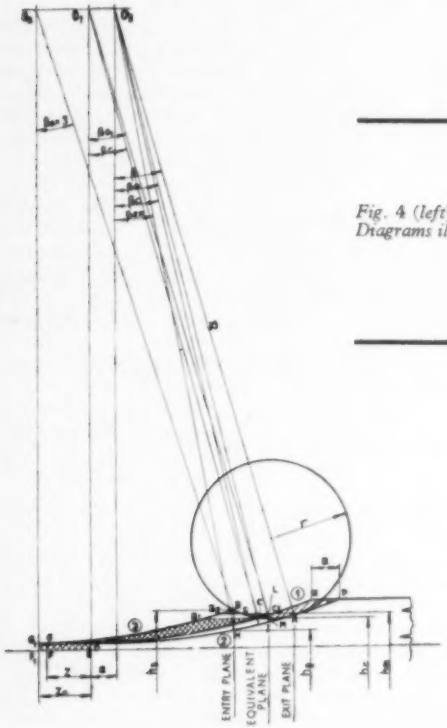
(2) The expressions for the displaced areas, on account of their shape, particularly considering the curved portions below the rolls, are rather complex.

To obtain a practical result, it is necessary to resort to calculating devices. One of these is to obtain first an imaginary displacement "z_a" and from this to determine a value of "z" by first approximation and subsequently a more correct value by second approximation.

For the sake of brevity, the complete development of the analysis will be omitted, confining the treatment to giving the resulting expressions, which are used for numerical calculation of the values of "z."

For clarity, the symbols used and their meaning will first be tabulated (*see* also Figs. 4, 5 and 7).

r = radius of the planetary rolls.
R = radius of the envelope over the planetary rolls.
a = advance of slab between successive impacts of planetary rolls.
H = thickness of slab.
h = thickness of strip.
h_a = thickness of slab corresponding to the intersection of the curve (1) with the planetary roll.
h_m = thickness of slab corresponding to the centre of the arc intercepted on the planetary roll between the curves (1) and (3).
h_2 = thickness of the slab on curve (2) in the plane of entry.
h_3 = thickness of the slab on curve (3) in the plane of entry.
"z_a" = imaginary value of the horizontal advance of the curved surface of the slab.



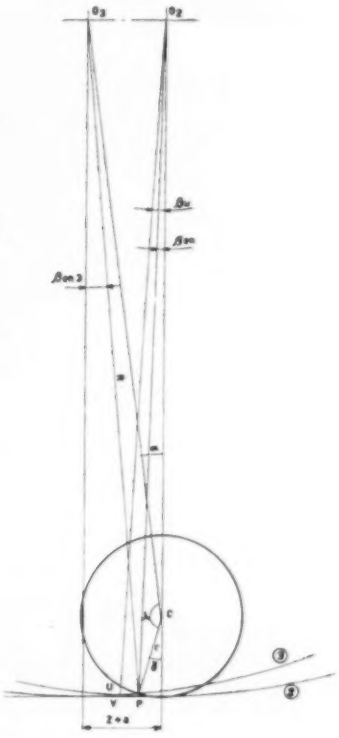


Fig. 4 (left) and Fig. 5 (right).— Diagrams illustrating symbols used in text

"z" = (real) horizontal advance of the curved surface of the slab from position (1) to position (3).

V_R = peripheral velocity of the envelope circle surrounding the planetary rolls.

V_o = horizontal velocity of exit of the strip.

β = angle to the vertical of the centres of the radius to the centre of the planetary roll in its general position.

β_e = angle as above, of the radius to the intersection of the equivalent plane with the curve (1).

β_{o1} = angle to the vertical of the radius passing from O_1 to the intersection of the equivalent plane with the curve (1).

β_o = angle as above of the radius passing from O_2 to the intersection of the vertical plane passing through C with the curve (2).

β_{c1} = angle as above of the radius passing from O_1 to the point C.

β_{en} = angle as above of the radius passing from O_2 to the intersection of the entry plane with the curve (2).

$\beta_{en\,3}$ = angle as above of the radius passing from O_3 to the intersection of the plane of entry with the curve (3).

δ = radial draft for each position of the roll, measured along the radius passing from O_2 to the intersection of the plane of entry with the curve (3).

l = arc of contact on the planetary roll.

φ = angular aperture of l.

F = radial roll load.

ε = angle of F with reference to the vertical.

M = torque opposing the rotation about O_2 of a single roll.

P = rolling power for a single roll.

S = horizontal force required to overcome the force F exerted by a pair of rolls, or the counter-thrust.

β_{inv} = angular position of the planetary roll in which reversal of direction of the horizontal component of F takes place.

β_{max} = angular position of the planetary roll in which the draft is a maximum.

The series of expressions required for the calculation of the displacement of the strip "z" is as follows :—

$$\beta_e = \beta - \frac{2}{3}\,\frac{\sqrt{2r.a.\sin\beta}}{R} \qquad \ldots\ldots\ldots\ldots\ldots\ldots(3)$$

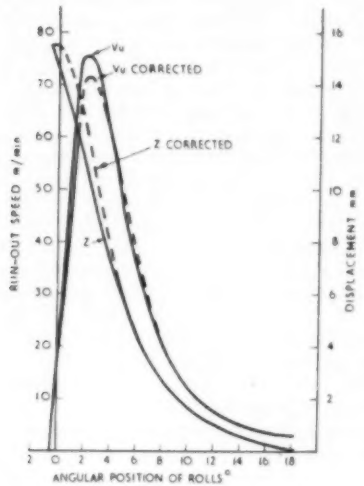
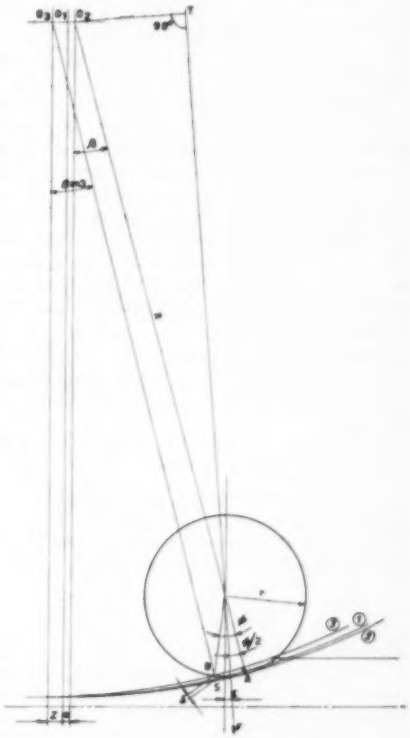


Fig. 6 (left).— Graphs of run-out speed and angular position of rolls

Fig. 7 (right).— Further diagram illustrating symbols used in text



$$\sin \beta_{e1} = \frac{a}{R} + \sin \beta_e \quad \ldots\ldots(4)$$

$$\beta_e = \beta - \frac{\sqrt{2r.a.\sin\beta}}{R} \quad \ldots\ldots(5)$$

$$\sin \beta_{e1} = \frac{a}{R} + \sin \beta_e \quad \ldots\ldots(6)$$

$$z_e = a\,\frac{H - h - R\,[(1-\cos\beta_e)+(1-\cos\beta_{e1})]}{h + 2R\,(1-\cos\beta_{e1})} \quad \ldots\ldots(7)$$

$$\beta_m = \beta - \frac{\sqrt{2r.\,(z_e + a)\,.\sin\beta}}{R} \quad \ldots\ldots(8)$$

$$\sin \beta_{m3} = \frac{z_e + a}{R} + \sin \beta_m \quad \ldots\ldots(9)$$

$$z = z_e\left[1 + \frac{\cos\beta_{m3} - \cos\beta_{e1}}{\frac{h}{R} + (1-\cos\beta_{e1}) + (1-\cos\beta_{m3})}\right] \quad \ldots\ldots(10)$$

In a second approximation, the calculation of (8), (9) and (10) can be repeated, using the value of "z" thus obtained instead of "z_e."

It is seen that $z = z_e$ when $\beta_{m3} = \beta_{e1}$, or when BC is horizontal (*see* Fig. 4).

The thicknesses of the slab in the plane of entry, referred respectively to curves (2) and (3) are :—

$$h_2 = h + 2R\,(1 - \cos\beta_m) \quad \ldots\ldots(11)$$

$$h_3 = h + 2R\,(1 - \cos\beta_{m3}) \quad \ldots\ldots(12)$$

In the position $\beta = O$, equation (8) would give a value of $\beta_m = O$, which is inexact. It is necessary, therefore, to apply another calculation which is more elaborate but accurate.

As the value for "z" in the first approximation, it is possible to put :—

$$z_1 = a\,\frac{H - h}{h} \quad \ldots\ldots(13)$$

from which, referring to Fig. 5, it is possible subsequently to calculate :—

$$\cos\lambda = \frac{(z_1 + a)^2 + (R - r)^2 + r^2 - R^2}{2r\,\sqrt{(z_1 + a)^2 + (R - r)^2}}$$

$$\tan\alpha = \frac{z_1 + a}{R - r}$$

$$\gamma = 180 \text{ deg.} - (\alpha + \lambda)$$

$$\beta_m = \frac{\gamma\,r}{R}$$

With β_m thus determined, it is possible to proceed as usual with equations (9) and the following.

As a consequence of what has been already explained, the planetary roll does not release the slab exactly on the vertical between the centres but lags in contact and thus continues to exert its force for a small fraction of time beyond this position.

It is interesting to determine the (negative) angular position in which the roll releases the slab, which will be called β_u. It is apparent that the *total* displacement of the strip, due to the entire action exerted by a single roll, when it has completed its pass, is given by equation (13), stated above.

Hence, the distance O_2O_3 at the end of the pass will be :—

$$z_1 + a = a\,\frac{H}{h}$$

and, referring to Fig. 5 in which O_3 represents the position at the end of the pass, then :—

$$\beta_u = \frac{z_1 + a}{2R} = \frac{a.H}{2R.h} \quad \ldots\ldots\ldots\ldots\ldots\ldots (14)$$

The length of the arc of contact with the slab is greater than would correspond to the angle of bite α_1 the value of which has been given initially by equation (1). Hence :—

$R(\alpha_1 + \beta_u)$.

When the roll has reached position β_u, obviously the speed of the strip V_u is reduced to zero, and also the draft δ, and with it the force, the torque, the power and the counter-thrust ; whereas, as already stated, the displacement attains its maximum value, already given by (13).

(2) *Exit Speed of the Strip*, V_u

The speed of exit of the strip, V_u, can be derived from the curve of the displacement " z " remembering that :—

$$V_u = \frac{dz}{dt} = \omega \frac{dz}{d\beta}$$

or, it can be calculated by approximation, as a function of the rate of deformation of the slab and of the instantaneous percentage reduction in the pass, according to the expression :—

$$V_u = \frac{h_3 - h_2}{h_3} . V_3 \cos \beta \quad \ldots\ldots\ldots\ldots\ldots (15)$$

(3) *Specimen Calculation*

Using the group of equations obtained, from (3) to (10), it is possible to calculate the successive values of the displacement " z " of the strip, for the successive positions of the planetary roll, and for any size of rolling mill or any combination of operating variables (thickness of slab, thickness of strip, rate of advance of the slab). It is a rather long and tedious calculation, both because it cannot be completed by means of a single formula but must be determined successively for each assumed value of the angle β, *i.e.*, all the values to which equations (3) to (10) refer, and because, to know how " z " varies during a roll pass, it is necessary to introduce a considerable number of assumed points, or to repeat the calculation for several positions, *i.e.*, values of β. In other words, it is a question of calculating about 400 numerical values which with the successive approximations required for the small angles, may easily increase to 450 to 500. On the other hand, it is not possible to adopt any other procedure without some loss of accuracy and completely falsifying the deductions following.

It should be observed further that the calculating procedure is such that in itself it provides no " *a priori* " indications as to the variation of " z " along the arc of contact. It is necessary to make the numerical calculation for a particular case, and to enter the values obtained in a diagram, to obtain a general idea and to draw the corresponding conclusions.

In order to give an idea of the results to be obtained with the method illustrated here and of the development of the two quantities considered up to the present, the calculation has been completed, taking diameter and thickness values appropriate for a rolling mill of 1,000 mm. (39.37 in.) width by

TABLE I—*Calculation of V_u, the Run-out Speed of the Strip from the Mill*

Data : Strip thickness 72 mm. (2.83 in.). Thickness in the run-out 3 mm. (0.118 in.). Envelope radius of planetary rolls 686 mm. (27 in.). Radius of planetary rolls 76 mm. (2.96 in.). Intermittent advance 0.68 mm. (0.027 in.). Angle of contact 18 deg. 15 min. Speed of cage 87.54 r.p.m. Peripheral speed of envelope of planetary rolls 378 m. per min. (1,240 ft. per min.) One roll only on arc of contact

	Value													
1	ß (deg.)	18	16	14	12	10	8	6	4	3	2	1	0	−0.41
2	Bo (Eq. 3) (deg. min.)	17.41[8]	15.42[2]	13.43[8]	11.44[6]	9.45[9]	7.47[4]	5.49[1]	3.50[6]	2.52[0]	1.53[5]	0.55[4]	0	−0.41
3	ßo1 (Eq. 4) (deg. min.)	17.44[6]	15.45[7]	13.46[8]	11.48[0]	9.49[4]	7.50[9]	5.52[4]	3.54[2]	2.55[4]	1.56[9]	0.58[8]	0.03[4]	—
4	z_c (Eq. 7) (mm.) ..	0.039	0.220	0.476	0.870	1.44	2.42	4.11	7.23	9.55	12.25	14.50	15.65	—
5	$ß_m$ (Eq. 8) (deg. min.)	17.30[8]	15.29[3]	13.27[8]	11.24[5]	9.22[6]	7.19[5]	5.15[3]	3.13[9]	2.15[4]	1.20[5]	0.30[0]	−0.19[6]	−0.41
6	$ß_{m3}$ (Eq. 9) (deg. min.)	17.34[7]	15.33[9]	13.33[8]	11.32[8]	9.32[7]	7.35[1]	5.40[5]	3.53[7]	3.04[9]	2.19[4]	1.37[6]	0.56[8]	0.41
7	z (Eq. 10) (mm.) ..	0.040	0.225	0.491	0.905	1.51	2.56	4.31	7.25	9.16	11.27	13.06	14.72	15.65
8	h_3 (Eq. 12) (mm.) ..	67.10	53.35	41.20	30.77	22.00	15.00	9.73	6.17	4.99	4.13	3.55	3.18	3.08
9	V_u (Eq. 13) (m. per min.)	2.42	3.36	5.01	7.59	11.13	20.20	37.20	61.40	69.70	69.40	52.60	19.10	0

the SAFIM company in Milan. The numerical results are tabulated in Table I and plotted against the position of the working roll on the chart in Fig. 6.

It will be seen that on the same figure for angles of $\beta < 6$ deg., in addition to the full-line curve (not corrected), a second broken-line curve of the second approximation (corrected curve) is included, obtained by recalculating all the expressions from equation (6) onwards using the "z" values instead of the "z_e" values.

The shape of the curve V_w clearly shows how *the strip runs out from the mill stepwise, with a very appreciable variation in speed during the action of each roll.*

The concomitant action of a second roll somewhat modifies the development of V_w, as will subsequently be apparent.

To check the accuracy of the calculation, the mean, real exit speed of the strip has been compared with that obtained from the diagram in Fig. 6 (mean ordinate value).

In particular :—

Angle of contact, $\alpha_1 + \beta_w$ = 18 deg. 15 min. + 0 deg. 41 min. = 18.934 deg.

Time in passing, $t = \dfrac{18.934}{360 \times 87.54} = 6.015 \times 10^{-4}$ min.

Real mean speed, $V = 0.68.\dfrac{72}{3} \cdot \dfrac{10}{6.015} = 26$ metres per min.

Mean speed determined by graphical integration of the V_w diagram in Fig. 6 = 24.9 metres per min.

In view of the smallness of the discrepancy in the two results, it can be considered that the method explained is able to furnish sufficiently accurate results.

(4) *Radial Draft*

The radial draft is a value exactly defined in the case of ordinary rolling mills, where it represents the thickness of the layer which is removed in rolling on the two sides of the rolled product, since it is converted into lengthening of the strip. It is simply equal to half the difference between the initial thickness and the final thickness.

By analogy, it is possible to define the draft as the thickness of the layer which is progressively removed between curve (3) and curve (2), measured at the point of entry, normally to the surface, or along the radius O_3S (Fig. 7). It is clear from the above that this draft is in this case no longer constant as in ordinary rolling mills, but varies with the position of the roll, since, depending on the position of the roll, the lead of curve (3) with reference to (2) varies, and is then "$x+a$" while the inclination of the radius O_3S also varies.

This is, in fact, given by :—

$$\delta = BS = (x + a) \sin \beta_{m3} \quad \ldots\ldots\ldots\ldots\ldots\ldots (16)$$

Now as the roll moves from the approach position to the vertical, *i.e.*, for decreasing values of the angle β, then $(x + a)$ increases, $\sin \beta_{m3}$ decreases, and thus δ increases from its initial value to a maximum and again decreases until becoming zero in the position of breaking contact.

As in ordinary rolling mills, the length of the arc of contact on the planetary roll AB (Fig. 7) depends on the draft and consequently the rolling force and other dynamic factors.

The draft is, therefore, a governing factor; its maximum value will determine the maximum value of the force and power required for rolling, and its range of variation in the pass will provide an indication as to the amplitude of variation of the forces in play and thus the vibrations set up in the mill.

(5) *Rolling Force and Back-thrust*

As is known, the length of the arc of contact AB (Fig. 7) is given by :—

$$l = \sqrt{2r.\delta}$$

Indicating by p (kg. per sq. mm.) the unit resistance to deformation of the material, which is a function both of the chemical composition and of the temperature of the material as well as of the percentage reduction and the thickness/roll diameter ratio, and by b (mm.) the width of the slab, the instantaneous value of the force is given by :—

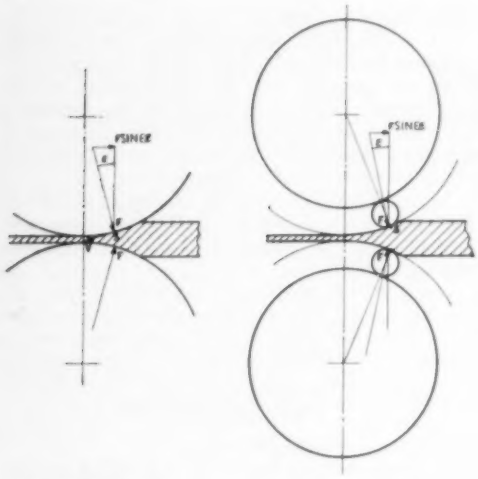
$$F = p.b.l = p.b.\sqrt{2r\delta} \quad \ldots\ldots\ldots\ldots\ldots\ldots (17)$$

This relationship is obviously identical with that obtaining for ordinary rolling mills, with, however, the essential difference that δ is not constant along the arc of contact of the envelope curve and furthermore neither is p. The variability of δ has already been mentioned. In regard to that of p it should be stated that with the advance of the roll, p increases, both because the percentage reduction δ/h_3 increases, and because the ratio rolled thickness h_3/roll diameter decreases.

The variation in p may be substantial, increasing as the rolled thickness decreases. In the absence, however, of precise data and to avoid excessive complications, p is considered, as a first approximation, to be constant for the whole duration of the pass, assuming for it the maximum value attained.

Equation (17) indicates that, for the same material conditions (temperature, strip width, roll dimensions) the force varies with the square root of δ, thus its variation is slower than the variation in the draft and the range of percentage reduction is also more restricted.

The force F at the start of the bite, is inclined in a direction opposite to that of the advance, with a counter-acting component equal to F sin ε in which the value of angle ε is given by (*see* Fig. 7):—



THE ROLLED PRODUCT HAS A SPEED V EQUAL TO THE PERIPHERAL SPEED OF THE ROLL

THE ROLLED PRODUCT IS FIXED AT POINT S. THE ROLL RUNS OVER IT BUT DOES NOT TEND TO PULL

$$\varepsilon = \beta - \frac{\varphi}{2} = \beta - \frac{1}{2r} = \beta - \frac{\sqrt{2\delta r}}{2r} = \beta - \sqrt{\frac{\delta}{2r}} \quad (18)$$

To counterbalance this force, which would tend to push the slab backwards thus making rolling impossible, an external backthrust must be applied, the value of which, for one pair of rolls is :—

$$S = 2F \sin \varepsilon \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (19)$$

It may appear at first sight that there is no difference here compared with conventional rolling. In this case also, in fact, the rolling force has a component always opposed to the feed motion, which tends to push the material backwards.

However, the frictional component neutralizes this backthrust and pulls the material forward.

In the particular case, sliding friction cannot play a part because the roll rotates over the material and, therefore, *without the intervention of an external force which holds the material pressed against the roll, the latter would push it back until it disengages* (*see* Fig. 8).

(6) *Back-torque and Rolling Power*

From Fig. 7, the arm of the force F is obtained with reference to the centre of rotation O_2 :—

$$O_2T = (R - r) \sin \frac{\varphi}{2} \simeq (R - r) \frac{\varphi}{2} = (R - r) \sqrt{\frac{\delta}{2r}}$$

The back-torque for a single roll is thus, for (17) :

$$M = p.b. (R - r) \delta \quad \ldots\ldots\ldots\ldots\ldots\ldots (20)$$

The power required for a single roll is consequently :—

$$P = \frac{M.n_a}{716} = \frac{p.b. (R - r) n_a}{716} . \delta \quad \ldots\ldots (21)$$

The same considerations apply here as were put forward in regard to the force F, concerning the variability of p and of δ.

It should be noted that while F varies with the square root of δ, M and P are directly proportional to δ and thus change more rapidly than F.

Fig. 8 (above.)—Diagram showing slab in rolls

Fig. 8 (a) (right).—Close-up view of rolls during the rolling process. The advancing slab at white heat, the rolling zone and the issuing rolled strip are shown

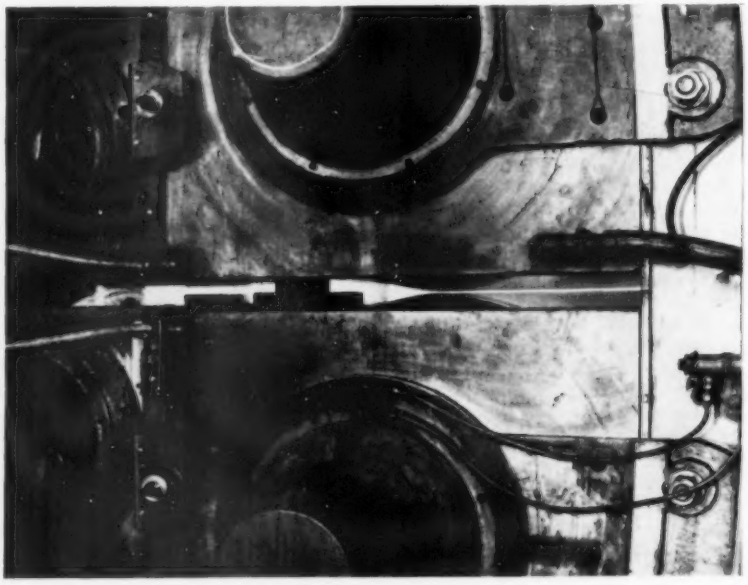


TABLE II—*Rolling Force, Opposing Torque and Backthrust*

Data : As in Table I. p = 14 kg. per sq. mm. (8.89 tons per sq. in.)

	Value													
1	ß (deg.)	18	16	14	12	10	8	6	4	3	2	1	0	− 41 min.
2	Draft δ (mm.) ..	0.218	0.243	0.274	0.316	0.363	0.427	0.494	0.538	0.531	0.530	0.455	0.276	0
3	Arc of contact l ..	5.75	6.08	6.45	6.92	7.41	8.05	8.66	9.05	8.98	8.65	7.90	6.47	0
4	Roll-separating force (tons)	80.5	85	90.3	97	103.8	112.7	121.0	126.5	125.6	121.1	110.6	90.6	0
5	ε (deg.)	15° 50′	13° 42′	11° 34′	9° 23′	7° 12′	4° 57′	2° 43′	0° 35′	−0° 23′	−1° 15′	−1° 59′	−2° 26′	− 41 min.
6	Counter torque M kg.	1860	2080	2340	2700	3100	3650	4210	4600	4540	4200	3500	2360	0
7	Backthrust P (tons)	44	40.3	36.1	31.6	26	19.4	11.5	2.58	−1.74	−5.32	−7.30	−7.65	0

In order to illustrate more fully the results obtainable by the method, the calculations previously made have been extended to cover the new quantities considered, the values given in Table II and the curves shown in Figs. 9 and 10 being obtained.

In Fig. 9, the "draft" curve rises from the entry up to an angular setting of about 3½ deg., where it attains a value equal to about 2.5 times the initial value. It then falls rather abruptly, reaching the initial value for $\beta = 0$ and falling to zero for $\beta = 0$ deg. 41 min.

The "back-torque" curve has been derived from the above by multiplying its ordinates with a constant factor. This procedure is somewhat rough and ready because, as already previously explained, the value of p in equation (20) can in no way be considered as even approximately constant. In reality, it increases with the progressive advance of the roll and, therefore, the curve should rise more rapidly than shown and the position of the maximum should be displaced towards the zero. Curve (1) is plotted for a constant value p = 14 kg. per sq. mm. (= 8.91 tons per sq. in.) which (according to *Siebel*) corresponds to a temperature of 1050° C. with a percentage reduction of 15 to 20 per cent.

In Fig. 10, the curve of the "arc of contact" is derived from the curve of the "draft" in Fig. 9 by a square-root relationship.

The "rolling force" curve has ordinates proportional to the preceding curve. This is accurate, assuming p is a constant, whereas in reality, what was stated above should be repeated, displacing the maximum further upwards and towards the zero.

The "back-thrust" curve intersects the axis of the abscissae in the position β_{ins} and in the region of the zero attains a maximum negative value of some magnitude, after which it reduces rapidly to zero. Here again, the ordinates should be higher, than those indicated as sloping towards the left, while the position β_{ins} is not influenced by the variation in the resistance to deformation p.

(7) *Maximum Force per Pass*

Examination of the rolling force and back-torque curves shows that the position corresponding to the maximum value of the force and the torque is somewhat near the vertical, *i.e.*, β_{max} is rather small.

The same applies to the position where the back thrust is reduced to zero, meaning that β_{ins} is also rather small.

When this is confirmed, the smallness of these angles makes it possible to use simplifying assumptions in calculating them. These assumptions will, of course, be valid only for the calculation of such small angles and not for the calculation of the complete curves for z, V_e and δ. These are based essentially on the substitution of the angles with their sines in the various equations.

In this way, the following series of equations is obtained :—

$$\beta_e = \beta - \tfrac{2}{3} \cdot \frac{\sqrt{2r}}{R} \cdot \sqrt{a} \cdot \sqrt{\beta} \quad \text{.....(3A)}$$

$$\beta_{e1} = \frac{a}{R} + \beta_e \quad \text{.....(4A)}$$

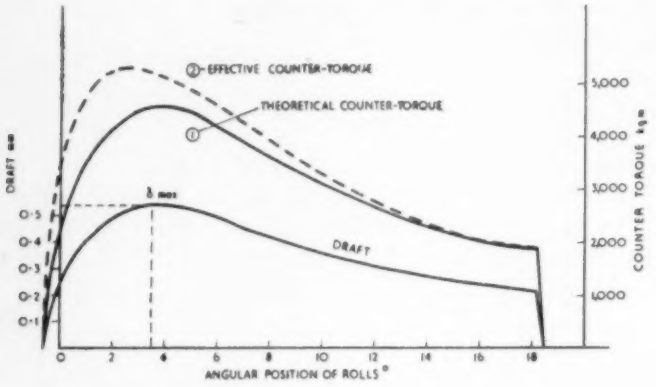
$$\beta_e = \beta - \frac{\sqrt{2r}}{R} \cdot \sqrt{a} \cdot \sqrt{\beta} \quad \text{.....(5A)}$$

$$\beta_{e1} = \frac{a}{R} + \beta_e \quad \text{.....(6A)}$$

$$z_e = a \cdot \frac{H - h - R\,(\beta_e{}^2/2 + \beta_{e1}{}^2/2)}{h + R \cdot \beta_{e1}{}^2} \quad \text{..(7A)}$$

$$\beta_m = \beta - \frac{\sqrt{2r}}{R} \sqrt{z_e + a} \cdot \sqrt{\beta} \quad \text{.....(8A)}$$

$$\beta_{m1} = \frac{z_e + a}{R} + \beta_m \quad \text{.....(9A)}$$



$$z = z_o\left\{1 + \frac{\beta_{e1}^2 - \beta_{en3}^2}{2h/R + \beta_{e1}^2 + \beta_{en3}^2}\right\} \quad \ldots\ldots\ldots(10A)$$

$$\delta = (z + a) \cdot \beta_{en3} \quad \ldots\ldots\ldots\ldots\ldots\ldots(16A)$$

The maximum value of the expression for δ cannot, however, be determined analytically by equating to zero the derivative $\frac{d\delta}{d\beta}$. Indications of the trend of δ_{max} can thus be obtained only by a series of numerical examples, the results of which will make possible the deduction of the laws of change with the operating variables and the dimensional variations of the rolling mill.

At this point it should be borne in mind that determination of δ_{max} is only of interest inasmuch as it is required for the determination of the force and of the power. Determination by graphical analysis has been made by the present author by calculating the values of δ for angles β varying by 1 deg. over the interval 1 to 6 deg., plotting the δ values thus obtained on a diagram and then determining the maximum point in the said diagram.

In the first case, the geometrical dimensions of the assembly were kept constant, one element only of the operating variables (slab thickness, strip thickness, slab advance or rate of feed) being varied individually about the value assumed for the calculations in Table I.

The same dimensional values, $r = 76$ mm., $R = 686$ mm., have also been considered.

In addition, the following operating values have been assumed :—

strip thickness

2	3	5	10	mm.
0.079	0.118	0.197	0.394	in.

slab thickness

65	72	79	mm.
2.56	2.83	3.11	in.

slab advance (feed)

0.52	0.68	0.84	1.04	1.56	mm.
0.020	0.027	0.033	0.041	0.061	in.

(corresponding to

1.00	1.30	1.60	2.00	3.00	m. per min.
3.28	4.27	5.25	6.56	9.84	ft. per min.

for the case of 22 planetary rolls rotating at 87.54 r.p.m.).

The values given in Table III and in the curves in Fig. 11 were obtained in this manner.

The curves clearly show the rate of change of the maximum draft with the thicknesses and the rate

Fig. 9 (*above*).—*Curves of angular position of rolls and draft*

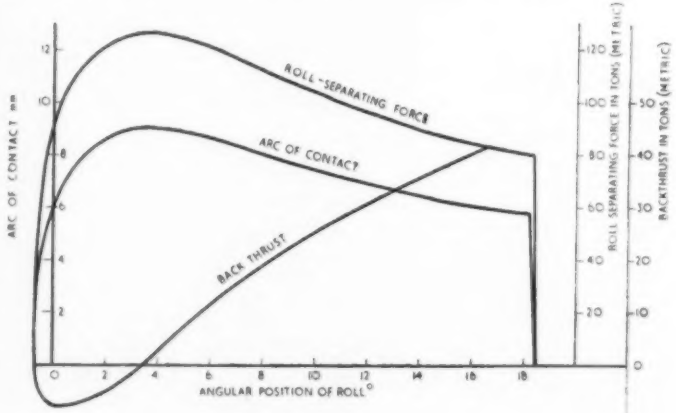


Fig. 10 (*right*).—*Curves of angular position of rolls plotted against arc of contact, roll-separating force and backthrust*

TABLE III—*Maximum Draft and its Angular Position in Different Operating Conditions*

Data : Slab thickness H as in Table. Strip thickness h as in Table. Envelope radius R = 686 mm. (27 in.) Radius of planetary roll 76 mm. Advance a as in Table.

(1) Slab thickness H = 72 mm. (2.83 in.).

	Maximum draft δ_{max} (mm.)				Angular position β_{max} (°)			
h (mm.)	2	3	5	10	2	3	5	10
a = 0.52 mm.		415				3° 35′		
0 68	0.772	0.550	0.415	0.290	2° 20′	3° 30′	4° 40′	7° 00′
0.84		700				3° 20′		
1.04	1.200	875			1° 40′	3° 00′		
1.56	2.020	1.420			0° 40′	2° 20′		

(2) Strip thickness h = 3 mm. (0.118 in.). Advance a = 0.68 mm. (0.027 in.).

H	Maximum draft δ_{max}	Angular position β_{max}
65	0.492	3° 30′
72	0.550	3° 30′
79	0.605	3° 30

of advance of the material within a restricted range around the assumed values. They indicate that, in general terms, that *the maximum draft*

(1) *increases proportionally with the increase in the rate of feed ;*

(2) *increases proportionally with the increase in the slab thickness ;*

(3) *increases exponentially with the decrease in the rolled thickness. In the 2 to 5-mm.* (0.079 to 0.197 *in.*) *range the variation can be formulated by the expression :—*

$$\delta max = \frac{K_3}{h^{0.7}}$$

In consequence, the maximum rolling force which for (17), other conditions being equal, varies with $\sqrt{\delta}$ can be expressed by a formula of the type :—

$$F_{max} = K_1 \sqrt{\frac{H.v}{h^{0.35}}} \quad \ldots\ldots\ldots\ldots\ldots\ldots (22)$$

where v represents the rate of feed.

On the other hand, the maximum counter-torque and hence also the rolling power, which vary with δ, can be expressed by a formula of the type :—

$$P_{max} = K_2 \frac{H.v}{h^{0.7}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (23)$$

As an example it can be said that, within the limits of the range in question, and with reference to predetermined working conditions, if :—

The slab thickness is increased by 20 per cent, the power increases by 20 per cent and the force by 10 per cent ;

The rate of advance is increased by 20 per cent, the power increases by 20 per cent and the force by 10 per cent ;

The strip thickness is decreased by 50 per cent, the power increases only by 33 per cent and the force by 15 per cent.

A second consideration based on the results given in Table III is that *the position of the maximum force* deviates rather rapidly from the vertical with increasing rolled thickness and a little less rapidly with a decrease in the rate of advance, while variations in the slab thickness have no appreciable influence.

In regard to the change in the value of the maximum force with the roll dimensions, if their diameters vary in such manner as to leave the ratio of their diameters unchanged, it is found that, when using the same calculating procedure, the position of the maximum force does not vary appreciably.

On the other hand, the value of the maximum force decreases as the fourth root of the radius of the envelope curve.

This result is interesting, because it is the opposite of what is found in ordinary rolling mills, in which the rolling force increases approximately with the square root of the roll diameters.

It must be plainly stated that in our case it is a question of variation in the envelope radius, *i.e.*, simultaneously in the diameter of the planetary roll and of the backing roll.

This point will not be emphasized further, since what is of interest is the total variation in the force and power, and not that due to a single roll ; therefore, with any variation of the roll diameter, the number of rolls simultaneously contacting the slab may vary.

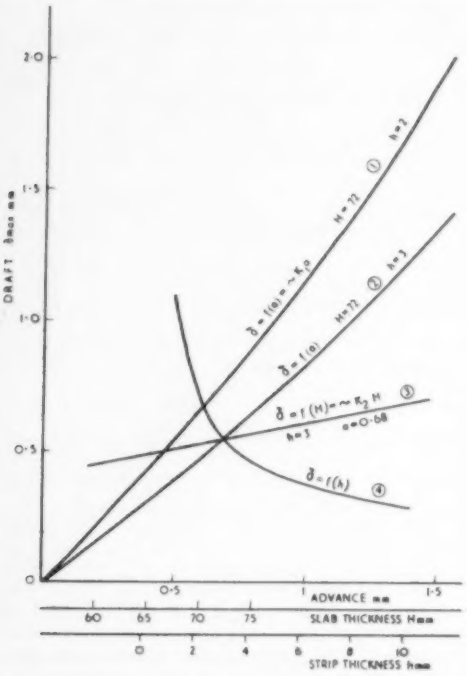


Fig. 11.—*Maximum draft as a function of the advance* (1) *and* (2), *of the slab thickness* (3) *and of the strip thickness* (4)

(8) *Reversal of the Back-thrust*

It is essential to note that, as is obvious from the curve in Fig 10, the horizontal component of F does not remain constant, as in ordinary rolling mills, but decreases with the advance of the roll until it drops to zero in a definite position. *From this point onwards, however, there is an active component which tends to carry the material forward.*

Before setting up the equations for this special case, it is desirable to examine the implications of this phenomenon.

It is indubitable that if the back-thrust tends to zero at a certain point and reverses its direction from this point onwards, rolling will not require any further aid from the mechanism feeding the slab forward.

It may be asked, however, whether annulling the back-thrust may mean that the slab is drawn forward by the planetary roll and that the driving mechanism is thus not only idling but is being carried along.

At first sight it may appear that such is the case but a more detailed examination explains precisely the facts of the matter.

It is possible to have recourse to an elementary scheme :—

The plate C_1 presses the roll C_2 against a plastic body B, bearing on a support in such manner that only the deformed part can advance without friction. The distance H_1 from C_1 to B determines the amount of reduction to which B is subjected. This value in turn determines the force to be exerted by C_1 on C_2. The plate C_1 advances at a rate v_1, the distance H_1 remaining constant (*see* Fig. 12*a*).

It is assumed that the adhesion between C_1 and C_2 is maintained in all cases either by a sufficient value of the coefficient of friction or by the action of a force generated between C_1 and C_2 independently of the reaction produced by the deformation of B.

The possible motions of C_2 are :—

(1) Advance with deformation of B by sliding at S ;

(2) Rotation, without deformation of B, with sliding at S ;

(3) Rotary advance or rolling, with deformation of B and adhesion at S.

It can be shown that, putting A_1, A_2, A_3 as the forces to be exerted, parallel to the motion of C_2 in the three above cases respectively, then at all times :—

$$A_3 < A_2 < A_1$$

and thus the motion of C_2 will always be a rolling motion if B is fixed, with a speed of advance $v_1/2$.

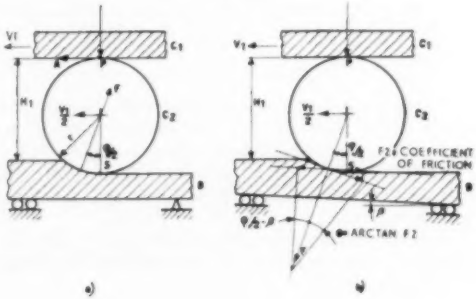
Suppose, however, that on the other hand, the supports of B are such as to permit it to travel without friction along a plane the normal of which is inclined through β with reference to the direction of P (Fig. 12*b*). The rolling force F should then be such as to have an active component

$$F \sin (\varphi/2 - \beta)$$

in the direction of the freedom of motion of B.

Note that if the speeds v_1 of C_1 and $v_1/2$ of C_2 remain constant, point S on the roll C_2 has zero speed and yet a possible motion of B will occur only with sliding at S between C_2 and B and thus with the development of a frictional force.

Fig. 12.—*Diagrams illustrating frictional situation when rolling*



In order that B can move it is hence necessary, however, that

$$F \cdot \sin(\varphi/2 - \beta) < F \sin\theta \cos(\varphi/2 - \beta)$$

or

$$\tan(\varphi/2 - \beta) > \sin\theta$$

where θ is the angle of friction at S between roll and slab.

The angle θ is always much greater than the value required to produce the above relationship.

Thus, it can be concluded that, if the speed of advance of the roll is kept constant, the slab cannot move forwards, as the active component of the rolling force seeks to constrain it, due to the action of the frictional resistance between roll and slab.

It must be noted, however, that this frictional resistance inherently tends to move the roll forward or to increase its instantaneous velocity, simultaneously slowing down its rotation.

If, therefore, the roll is free to advance with reference to the cage, *i.e.*, if there is precessional play and if the slab is free, the active component of the rolling force can move the slab forward, disengaging it from the following slab, prevented in this only by the inertia of the slab and the roll.

It is thus clear that in the general case in which, for a fraction of the rolling time, two contiguous rolls act simultaneously on the slab, the said action could influence the motion of the slab only should it occur before the succeeding roll has begun to grip. Otherwise it is neutralized by the counter-thrust of the latter which is always greater, and in this case the thrust required from the driving mechanism is never nullified, fluctuating between a maximum and a minimum.

Hence the importance of knowing the position β_{inv} at which the counter-thrust takes place. Independently from this consideration, special conditions exist for the tail end of each slab, the part shorter than the distance between two contiguous rolls. The pull of the rolls can act fully on it, which, assuming there is a precessional play, would produce a forward displacement of increasing value, the smaller is the bulk of the tail end which has to be pulled through while the rolling action continues. The last portion of the slab would thus become detached from the front end of the following slab, being subjected to a progressively increasing advance which, if the inertia forces permitted, might become twice the value of the precessional play measured along the circumference of the work-roll centres.

This justifies the increased power requirement arising during the transition from one slab to the next, because the successive rolls are required to make progressively deeper passes.

A second important consequence is that if the tail end of the slab is not constantly pressed by the front of the next slab, it is no longer supported and tends to drop by its own weight into the space between two rolls, for which reason the forces will no longer be equally distributed between the two rolls of a single pair, the lower roll being subjected to greater stress. This produces a tendency in the lower roll to lag with reference to the upper (a tendency to get out of synchronization).

As a result of the above, the existence of the precessional play is a source of trouble and instability during the transition phase, which is the more pronounced, the greater the amount of play.

If, on the other hand, the roll is blocked with reference to the cage, the active component of the rolling force tends to accelerate the motion of the cage.

It has, in fact, been confirmed that the cage speed with blocked chocks is greater.

The horizontal component of F, or back-thrust, decreases to zero at the position in which $\varepsilon = 0$, or, for (18), when

$$\beta = \sqrt{\frac{\delta}{2r}} \qquad \text{.....(18a)}$$

And, as for $\varepsilon = 0$, F is vertical and AB (Fig. 7) is horizontal, we also have :—

$$AB = z + a = O_3O_2$$

thus, in this position,

$$\beta = \beta_{m3} \qquad \text{.....(18b)}$$

The value of β at which the reversal of the back-thrust takes place is designated β_{inv} and it is determined by obtaining with the help of formulae (3) to (10) the values of β_{m3} in terms of β and then obtaining by interpolation the value for which (18b) is confirmed.

When, as generally occurs, the reduction to zero of ε corresponds to a sufficiently low β_{inv}, the calculation can be simplified and thus (18a) becomes for (16a) and (18b) :

$$\beta = \sqrt{\frac{(z + a)\,\beta_{m3}}{2r}} = \sqrt{\frac{(z + a)\,\beta}{2r}}$$

or :—

$$\beta_{inv} = \frac{z + a}{2r} \qquad \text{.....(24)}$$

$$\beta_{inv} = \beta_{inv}^2 \cdot 2r = \frac{(z + a)^2}{2r} \qquad \text{.....(24a)}$$

Using the same method already applied for δ_{inv} and for the same operating and dimensional values, a series of values of β_{inv} has been calculated.

The results obtained are given in Table IV and in the curves in Fig. 13.

The curves show how the point of reversal of the back-thrust in a rolling mill of specified dimensions moves away from the mill centre-line with increasing rate of advance, with increasing slab thickness and with decreasing strip thickness. This movement increases the range (Fig. 10) where the back thrust is negative and hence produces a *wider amplitude of alternation of the forces on the driving mechanism,*

TABLE IV—*Angular Position of Reversal of Backthrust with Different Working Conditions*

(1) Slab thickness H = 72 ; Roll radius r = 76 ; Envelope radius R = 686

h (mm)	2	3	5	10
a = 0.52		2° 59′		
0.68	3° 52′	3° 32′	2° 49′	1° 46′
0.84		3° 54′		
1.04	4° 37′	4° 18′		
1.56	5° 27′	5° 12′		

(2) Strip thickness h = 3 ; Advance a = 0.68 ; r = 76 ; R = 686

H =	65	72	79
	3° 17′	3° 32′	3° 38′

(3) H = 72 ; h = 2 ; a = 1.04

r	60	70	76
R = 625		4° 57′	
654	5° 08′		
686			4° 37′
786			4° 30′

the greater the value of the reduction in the thickness and the rolling speed.

In Section (3) of Table IV, some values of β_{inv} are given calculated for roll dimensions other than the above and it is seen that the roll dimensions have little influence on the reversal of the backthrust.

The point of reversal of the counter-thrust acquires considerable importance in the general case in which two contiguous rolls act simultaneously on the slab, as will subsequently be seen.

(9) *Corrugations in the Strip*

It is clear from the above and from Fig. 5 that when the roll loses contact in position β_{n2}, the thickness of the strip at the point of contact is not h, but h' greater than h and is defined by (12) and (14), since, also, $\beta_{en1} = \beta_n$ then :—

$$h' = h + 2R.2\sin^2\frac{\beta_{en1}}{2} = h + 4R\left[\frac{aH}{4Rh}\right]^2$$

$$= h + \frac{a^2H^2}{4Rh^2};$$

thus the strip thickness varies periodically between h and h' at intervals equal to

$$a\frac{H}{h}$$

and the percentage variation in thickness is :—

$$\frac{\triangle h}{h} = \frac{a^2H^2}{4Rh^3} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(25)$$

It is clear that the percentage value of the corrugations increases very rapidly with a decrease in the final rolled thickness (with the third power of the same).

For example, in the rolling mill under consideration up to the present, for a speed of 1.3 m. per min., with H = 72 and h = 2 mm. then :—

$$\frac{\triangle h}{h} = 11 \text{ per cent.}$$

If, on the other hand, h rises to 1 mm. with the same values, then :—

$$\frac{\triangle h}{h} = 88 \text{ per cent.}$$

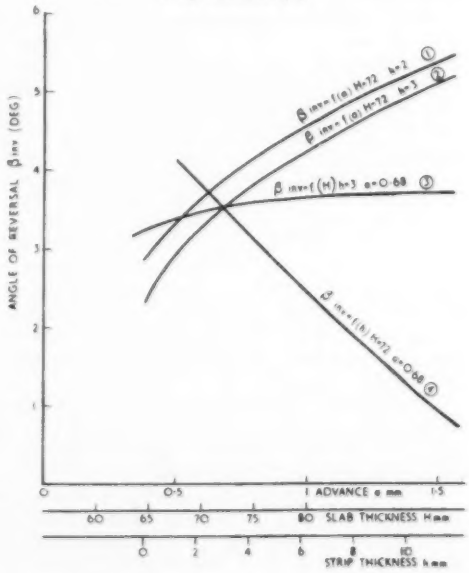
This degree of corrugation appears to be excessive and would certainly be harmful. In reality, the elasticity of the rolling mill, *i.e.*, the incomplete observance of hypothesis (3) ensures that the corrugations are held within far more reasonable limits.

PART II—FULL-SCALE ANALYSIS

Continuous Advance of the Slab : Two Pairs of Rolls on the Slab for a Fraction of the Contact Period

The conclusions arrived at up to the present are based on the assumption that the advance of the slab is discontinuous and occurs during the interval

Fig. 13.—*Point of reversal of the backthrust as a function of the advance* (1) *and* (2), *of the slab thickness* (3) *and of the strip thickness* (4)



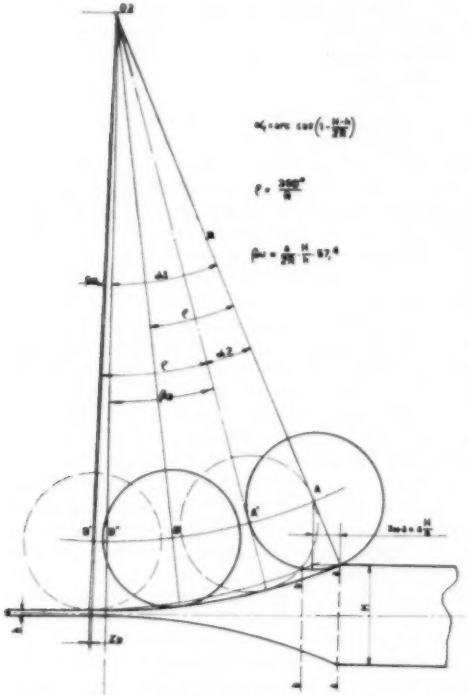


Fig. 14.—Diagram illustrating effect of variation in the roll gaps

between the contact of two successive rolls and that the contact itself occurs for a single pair of rolls simultaneously as stated above.

In a more general case (continuous advance of the slab), the position will be that the arcs of contact on the slab (curves (1), (2) and (3) in Fig. 3) are no longer circular but elongated cycloids.

Seeing, however, that the radius of the circle generating the cycloid is very small compared with the distance from the centre to the generating point (the ratio is 7/1000 with the values of Table I), with very good approximation it is possible to equate the cycloids to circular arcs and retain as entirely valid the arguments used and the formulæ derived hitherto.

The intervention of a second roll before the preceding has completed its action on the slab, on the other hand, involves considerable complications and the necessity arises of examining one by one the consequences to be derived :—

(1) Variation in the roll gaps ;

(2) Variation of the displacement "z" and of the run-out speed V_u ;

(3) Roll-separating force resulting from the action of the two rolls gripping simultaneously and vibration ;

(4) Opposing torque and power required ;

(5) Back-thrust required by the feed rolls.

(1) *Variation in the Roll Gaps*

It has been stated initially that in constructing a planetary mill, a certain freedom of tangential motion should be allowed for the planetary roll, *i.e.*, the roll should itself be able to move in the direction of its revolution. This freedom of motion, known as *precessional play*, is naturally always very small, *i.e.*, of a magnitude of not more than a millimetre.

The arrival of the second roll on the contact arc occurs at the point A (Fig. 14) when the first roll is at point B. Its displacement from A to A′ would occur simultaneously with the displacement from B to B″ if the distances were fixed.

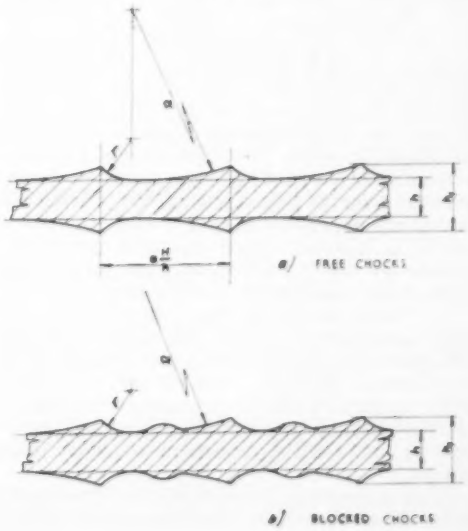
As, however, the displacement from A to A′ produces an advance of the strip z_p, the roll B is constantly constrained to advance with reference to A, and when it reaches B′, at the point at which it leaves the arc of contact, its distance from A has increased by z_p.

This value z_p (*precession*) is obtained by the usual procedure of determining the instantaneous strip displacement and corresponds to an angular position (A′ in Fig. 14).

$$\beta_2 = \rho - \beta_u$$

(disregarding z_p/R in view of its smallness compared with ρ, which is the angular distance between the planetary rolls).

Fig. 15.—Diagram showing effect of free and blocked chocks



If it is assumed, using extreme values still relating to the example given above, that :—

slab thickness H = 90 mm.
strip thickness h = 2 mm.
envelope radius R = 686 mm.
number of planetary rolls = 22
advance per roll, a = 1.04 (rate v = 2m.per min.)

the result is :—

angular distance of the rolls ρ = 16 deg. 21 min.
angle of entry α_1 = 20 deg. 37 min.
run-out angle β_u = 1 deg. 17 min.
angle of overlap α_2 = 5 deg. 32 min.

Ratio :

$$\frac{2 \times \text{contact time}}{\text{total contact time}} = \frac{\alpha_2}{\rho} = \frac{5 \text{ deg. } 32 \text{ min.}}{16 \text{ deg. } 21 \text{ min.}} = 34 \text{ per cent}$$

angular position of A corresponding to the run-out of roll B

$$\alpha_2 = 15 \text{ deg. } 4 \text{ min.}$$

In this position, the strip advance is z = 0.96 mm. and this is the required precessional play.

If, on the other hand, the working values are those given in Table I, the required precession is only 0.26 mm. and the ratio :

$$\frac{2 \times \text{contact time}}{\text{total contact time}} = 15.7 \text{ per cent.}$$

It can now be asked what happens if no allowance is made for any precession in the rolls, *i.e.*, if they are mounted with *blocked chocks*. In this case, as it still holds that the part of the slab nipped between the vertical planes *aa* and *bb* is subjected to an elongation z_r in passing from A to A′, according to the value of z_r it may happen that :—

(*a*) It is absorbed by the backlash between the different parts concerned and by the elastic yield ;

(*b*) There is compression of the slab accompanied by bulging in the zone of reduced thickness, *i.e.*, against the roll B, due to which, when the roll releases the slab at B′ a small ridge will be formed at its shoulder which, depending on its length, may or may not be subsequently removed during the passage of the roll A. This ridge changes the profile of the strip as is seen in Fig. 15, in which appear two different series of ridges, one in front of and one behind the impression of each working roll. The second is, however, always less pronounced than the first and thus it does not complicate the problem of the subsequent flattening of the strip ;

(*c*) There is lateral bending of the part of the slab lying between the two rolls, due to point stresses. The bending is then checked by the passage of the next pair of rolls over it and the result is only a slight increase in the power required on account of this work of deformation. This case occurs only for such small thicknesses as to develop point stresses.

If the rolling mill is sufficiently free from backlash and entirely stiff, the case (*b*) is encountered and then the bearings of the planetary rolls should withstand the force producing the axial compression of the slab which force can set up high stresses in the rolling mill.

(2) *Variation in the Strip Displacement and the Run-out Speed*, V_u

Referring to Fig. 14 and to the diagrams in Fig. 6, it is clear that in the sections of the arc of contact in which the rolls are in the bite simultaneously, their actions are superposed and consequently, the displacement "z" and the run-out speed V_u will be determined by the sum of the two values applicable to the single rolls.

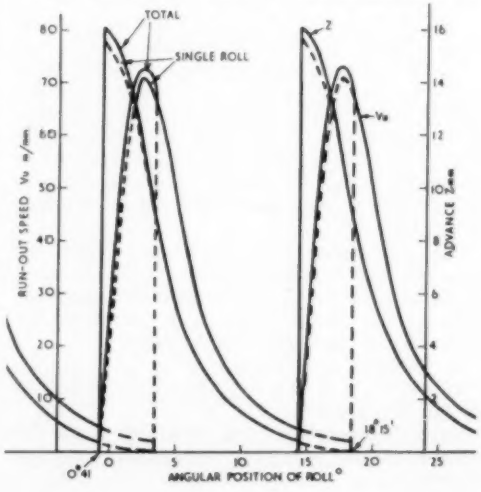
By superposing diagrams such as those given in Fig. 6 at an angular distance equal to the axial spacing of the rolls, the resulting diagram which will be of the type of that given in Fig. 16 is obtained easily. In this figure, it is assumed for the sake of clarity the planetary mill has 24 rolls instead of 22, as assumed hitherto. In the case considered, of 3 deg. 56 min., the superposition is equal to 26 per cent of the angular distance between the rolls and the increase in z and in V_u by the action of the second roll is somewhat restricted, being less than 2.5 per cent.

With 22 rolls, this increase is obviously even less.

(3) *Resulting Rolling Force. Vibrations*

If there is no bulging of the slab in consequence of the compression produced by the simultaneous action of the two rolls, the draft is not influenced by the presence of the second roll and thus the rolling force and the torque required remain unchanged.

Fig. 16.—*Run-out speed of strip and instantaneous strip displacement for* 1-2 *contact* (24 *planetary rolls*)



The force on the backing roll, however, will be the geometrical resultant of the single forces and, in view of the smallness of the angular values of ε,

$$R = \sim (F_1 + F_2)$$

A purely algebraic calculation of the resultant force is not convenient, however, in view of the complexity of the procedure. Graphical analysis is at once seen to be the more convenient, and consists in plotting two curves similar to those in Fig. 10 at a distance equal to the gap between the rolls and adding the ordinates of the superposed parts of the curve, obtaining a curve the appearance of which will be as in Fig. 17.

If it is required to know only the mean value of the force, the procedure is more simple. It is sufficient to determine the mean single force, represented by the mean ordinate of the curve in Fig. 10 and increase it by the percentage overlap, or the ratio

$$\frac{\alpha_2}{\rho} = \frac{\text{2 contact angle}}{\text{angular distance between the rolls}}$$

to obtain the mean total force.

In other words, given :—

F_t = mean total force

F_s = mean single force

then

$$F_t = F_s \left(1 + \frac{\alpha_2}{\rho} \right) = F_s \left(1 + \frac{\alpha_1 + \beta_u - \rho}{\rho} \right)$$

$$= F_s \frac{\alpha_1 + \beta_u}{\rho}$$

It can be noted that, in the example given in Fig. 17, still retaining the values previously used, the maximum total force is only 58 per cent greater than the maximum single force and not double, as would be the case, for instance, if the force were constant.

The mean force, on the other hand, is increased only 15 per cent by the presence of the second roll.

It is to be observed, moreover, that between the minimum and the maximum of the total force, the ratio is 1 : 2.4.

If the two curves do not become superposed, which may happen if the number of rolls is reduced or the amount of the reduction in thickness, until a 0-1 contact is obtained, a lower value of the maximum force, other conditions being equal is obtained, but the percentage variation in the force is rather greater because it goes from 0 to its maximum value, thus at an infinite ratio.

Therefore, *the stresses in the planetary mill, far from being constant, are of a pulsating character with a frequency determined by the number of rolls passing over the slab in unit time*, i.e., frequency = number of rolls × revolutions of cage *and with an amplitude of oscillation which varies from case to case*, depending on the operating conditions, in the specific case varying from 0.71 to 1.7 times the mean values.

At this point it can be asked and it is a question of the greatest interest—by what means this amplitude of oscillation can be reduced. Clearly the further the maximum of the single curve is removed from the region of superposition of the two curves, the more the maximum total value decreases.

An increased strip thickness and a reduction in the rate of advance act in this sense inasmuch as both these variations move the point of maximum force towards greater values and hence further from the region of superposition.

Since, however, the curve of the force is very steep from the maximum to zero, these remedies are not very effective.

Varying the roll diameters so as to leave their ratio unchanged has little effect on the position of the maximum force.

A far more effective reduction in the vibrations can be obtained if instead of a 1-2 contact, the dimensions are such as to produce a 2-3 contact. In this case, as can be surmised, instead of a ratio of 1 : 2.38 between minimum and maximum force, a ratio 1 : 1.5 can be obtained easily.

The simultaneous action of three rolls produces other consequences, however, which have not yet been completely investigated. At present no rolling mills have been constructed in which 2-3 contact is obtained.

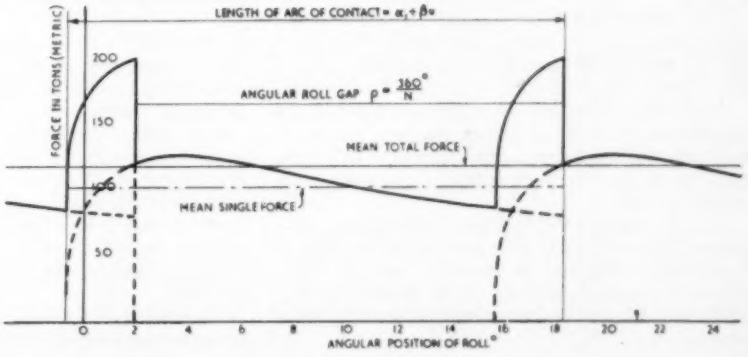


Fig. 17.—Total rolling force (22 planetary rolls)

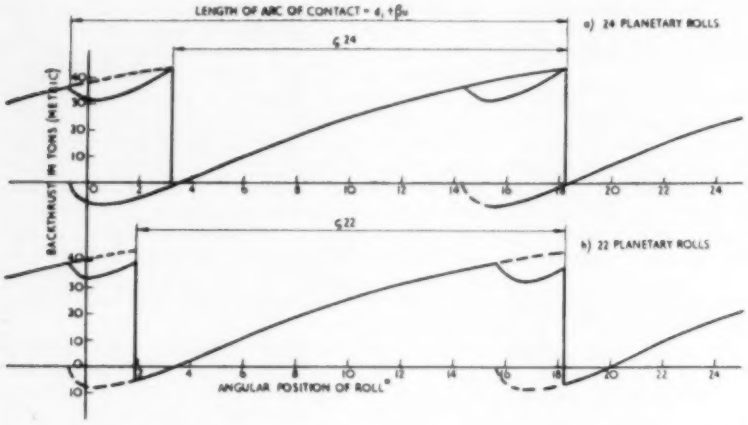


Fig. 18.—Total back-thrust (a) 24 planetary rolls and (b) 22 planetary rolls

To sum up :—

(*a*) The vibrations are induced by the pulsations of the stresses natural to the particular mill ;

(*b*) An increase in the rolled thickness and a decrease in the rate of feed reduces the amount of vibration.

(*c*) The most effective remedy is to increase the number of rolls gripping simultaneously.

(4) *Back-thrust Required from the Feeding Rolls*

It has been shown in the preceding section how the back-thrust exerted by the planetary rolls on the slab is reversed at a certain point and thus becomes a positive force.

Superposing the action of the two rolls as has already been done for the force and for the torque, the cyclic diagram of the back-thrust is produced as shown in Fig. 18. It can be seen that the extent of the superposition is of even greater importance here than in the previous cases.

In fact, to obtain steady running and to reduce the amount of longitudinal horizontal vibration influencing the feed rolls, it is desirable to create conditions such that the back-thrust is never reduced to zero.

This is obtained if the angular gap between the rolls is less than the width of that part of the contact arc in which the back-thrust is positive, *i.e.*, if

$$\rho < \alpha_1 - \beta_{lav} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (24)$$

As in order to reduce ρ it is necessary to increase the number of rolls, we obtain a second confirmation that *the functioning of the planetary mill is the more steady and free from vibration, the greater the number of rolls.*

Fig. 18 shows two diagrams, one relating to a group consisting of 22 rolls and the other relating to 24 rolls. Whereas in the first case the back-thrust is reversed over an arc of about $1\frac{1}{2}$ deg., in the second case the back-thrust never falls below zero.

If the characteristic of steady running is represented as an angle θ which is :—

$$\theta = \alpha_1 - \beta_{lav} - \rho$$

then steady running is obtained in conditions in which :—

$$\theta > 0$$

Again returning to the examples already used and the results given in Table IV and considering three cases, *i.e.*, 26 rolls, 24 rolls and 22 rolls, the θ values given in Table V are obtained. These values are the more above zero and thus *running is steadier the lower the rate of feed, the greater the rolled thickness and the greater the slab thickness.*

This means that confirmation of the means to be adopted to ensure steady running has been found in a different way.

It should be stressed that *to obtain increased steadiness, the slab thickness can be increased.*

Thus, for instance, if with a set of 24 rolls, rolling slabs from 72 mm. (2.83 in.) to a final 2 mm. (0.79 in.) with an advance per roll of 0.68 mm. (0.027 in.) the angle θ is equal to -0 deg. 29 min. ; for slabs of 79 mm. (3.11 in.), leaving other conditions unchanged, the angle β_{lav} increases only by 6 min., whereas the angle α_1 increases by 55 min. and thus θ increases by 49 min. and becomes positive, *viz.*, $\theta = 0$ deg. 20 min.

It is advisable at this point to stress that the reversal of direction of the back-thrust does not necessarily imply that the driving mechanism begins to be driven rather than to drive. In fact, in the case in which it comprises a pair of feed rolls, the thrust results from an associated reduction in the slab thickness and thus the force required in the driving gear is only part of the force required to push the slab forward, the remaining part being the force required for the work of deformation on the slab.

Thus even if the first part is reduced to zero, or rather is reversed, the second remains and it

TABLE V—*Characteristics of Stability of Backthrust*
R = 686. r = 76. ρ_{26} = 13° 51′. ρ_{24} = 15°. ρ_{22} = 16° 22

		α_1	β_{lim}	θ 26	θ 24	θ 22
H = 72 h = 3	a = 0.52	18° 15′	2° 59′	1° 25′	0° 16′	−1° 6′
	= 0.68	18° 15′	3° 32′	0° 52′	−0° 17′	−1° 39′
	0.84	18° 15′	3° 54′	0° 30′	−0° 39′	−2° 1′
	1.04	18° 15′	4° 18′	0° 6′	−1° 3′	−2° 25′
	1.56	18° 15′	5° 12′	−0° 48′	−1° 57′	−3° 19′
H = 72 a = 0.68	h = 2	18° 23′	3° 52′	0° 40′	−0° 29′	−1° 51′
	3	18° 15′	3° 32′	0° 52′	−0° 17′	−1° 39′
	5	17° 58′	2° 49′	1° 18′	0° 9′	−1° 13′
	10	17° 17′	1° 46′	1° 40′	0° 31′	−0° 51′
h = 3 a = 0.68	H = 65	17° 42′	3° 17′	0° 34′	−0° 35′	−1° 57′
	72	18° 15′	3° 32′	0° 52′	−0° 17′	−1° 39′
	79	19° 10′	3° 38′	1° 41′	0° 32′	−0° 50′
H = 72 h = 2	a = 0.68	18° 23′	3° 52′	0° 40′	−0° 29′	−1° 51′
	1.04	18° 23′	4° 37′	−0° 5′	−1° 14′	−2° 36′
	1.56	18° 23′	5° 27′	−0° 55′	−2° 4′	−3° 26′

would be necessary, if the feed assembly is to drag, for the former part (now negative) to exceed the latter, which is not the case.

(5) *Counter-torque and Power Required. Energy Balance*

The same method used to derive the total rolling force from the single force can be used for the counter-torque.

Here, putting :—

M_t, P_t, M_s, P_s,

the *mean* total torque and power respectively, and the *mean single* torque and power :—

$$M_t = M_s \frac{\alpha_1 + \beta_{lim}}{\rho}$$

$$P_t = P_s \frac{\alpha_1 + \beta_{lim}}{\rho}$$

In the example given in Fig. 19, it can be seen that the maximum torque (and power) is 30 per cent greater than the maximum single torque (and power) whereas the mean torque (and power) are still increased by 15 per cent only, owing to the effect of the second roll. The variation from minimum to maximum is between 0.58 to 1.67 of the mean value. The power we have been considering up to the present is only that required for the work of deformation of the material, without taking frictional forces into account. To define this, and by applying the usual example, it is possible to obtain from the values in Fig. 18, on the basis of the formula :—

$$\frac{P = M_t \cdot n_a}{716}$$

with Mt = 3,600 kg. (7,937 lb.)

n_a = 87.54

the (theoretical) rolling power required, equal to 880 h.p.

Summarizing what has been said hitherto and confirming the acceptability of the method presented by the present author, a short check calculation will be made, using the same data as assumed in the examples already considered, *i.e.*, those relating to the SAFIM 1,000-mm. (39.37-in.) mill.

The complete energy balance will take account of all the frictional forces in addition to the useful energy of rolling and it is required to confirm whether the calculation furnishes a value for the power required equal to that actually absorbed in the tests.

The applicable data for a predetermined rolling programme were :—

Slab temperature (in the planetary mill), 1,000° C.

The resistance to deformation at this temperature can be taken as p = 16 kg. per sq. mm. (10.2 tons per sq. in.).

Slab thickness H = 75 mm. (2.95 in.).

Strip thickness h = 3.7 mm. (0.146 in.).

Strip width b = 1,000 mm. (39.37 in.).

Rate of feed v = 1.4 m. per min. (4.59 ft. per min.)

Using equations (22) and (23) the rolling force and the counter-torque relative to the particular rolling conditions can be obtained.

In fact, from Fig. 17 and 18, when H = 72 mm. (2.83 in.) h = 3 mm. (0.118 in.) v = 1.3 m. per min. (42.6 ft. per min.) p = 14 kg. per mm. (784 lb. per in.), then :—

F_t = 118 metric tons ; M_t = 3,600 kg. (7,937 lb.).

With the new conditions, on the other hand, the calculation gives :—

$$F_t = 118 \times \sqrt{\frac{75}{72}} \times \sqrt{\frac{1.4}{1.3}} \times \left(\frac{3}{3.7}\right)^{0.35} \times \frac{16}{14}$$

= 133 metric tons

$$M_t = 3{,}600 \times \frac{75}{72} \times \frac{1.4}{1.3} \times \left(\frac{3}{3.7}\right)^{0.7} \times \frac{16}{14}$$

= 3,960 kg. (8,730 lb.).

In addition:

Maximum power output of rolling mill = 3,000 h.p.

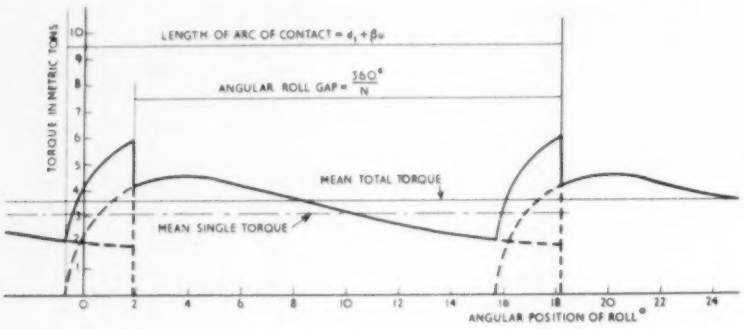


Fig. 19.—Total counter-torque (22 planetary rolls)

Current take-off for this power = 440 amp.
Current take-off for no-load = 40 amp.
Current take-off in the specified rolling conditions = 280 amp. equal to a power take-off of 1,900 h.p.
Hence :—

(1) Losses by friction in the bearings of the planetary rolls, the cage bearings and oil gaskets, *i.e.*, the losses under no load $3{,}000 \times \frac{40}{440} = 272$ h.p.

(2) Frictional losses in the gear-box 2 per cent, equal to 38 h.p.

(3) Frictional losses in the main bearings, diameter 500 mm. (19.69 in.), assuming a coefficient of friction of 0.0035 are equal to $2 \times 0.0035 \times 133{,}000 \times 0.250 \times \frac{200}{716} = 65$ h.p.

(4) Frictional losses between the gripping planetary rolls and the backing roll.

The coefficient of friction to be assumed in this case is very uncertain because surface conditions vary as between rolls recently machined and worn rolls.

For average conditions, a coefficient of 0.025 is assumed.

The frictional loss is in this case : $2 \times 0.025 \times 133.000 \times 0.534 \times \frac{112.5}{716} = 560$ h.p.

(5) Power required for the work of deformation : $P = 2 \times \frac{3{,}960 \times 87.5}{716} = 965$ h.p.

Thus the total power required is, by calculation : $P_t = 272 + 38 + 65 + 965 = 1{,}900$ h.p.

This value corresponds exactly with the current take-off measured during operation, and thus confirms the suitability of the author's method of analysis.

It should be noted that the percentage distribution of the power used is as follows :—

	Per cent
Useful power 965 h.p. equivalent to ..	51
Friction between the rolls, 560 h.p., equivalent to	30
Sundry frictional losses	19
	100

From these figures it is clear that to keep the power take-off low and hence the energy required, it is important to keep the roll surfaces properly true so that the coefficient of friction in rolling does not reach an excessively high value.

CONCLUSION

An elementary analysis of the deformation phenomena within a planetary rolling mill has been given, obtaining mathematical relationships linking the displacements, deformations, speeds, forces, torques and powers, *i.e.*, all the kinematic and dynamic characteristics which we wish to determine.

The elementary theory has been applied, first to the case of a single roll, then to the general case of several rolls acting simultaneously in such manner that their effects are superimposed and it has shown how the values of the different quantities can be calculated, using the method of graphical analysis.

It has also been shown by examples how certain mathematical expressions can be used to illustrate some of the particular and more interesting phenomena of such a rolling process ; for instance, the vibration conditions, the surface corrugations and the reversal of the back-thrust.

However, only the fringes of the subject, which lends itself to far more detailed investigation, have been touched.

Many other phenomena can be elucidated by the theory developed and other phenomena can be

(*Continued in page* 511)

predicted. This theory should certainly also show the way to further improvements.

The author, therefore, hopes that he has made some contribution to the development of this method of rolling, which, originating as a brilliant idea on account of the extreme simplicity of its implications, after its first somewhat tentative advances, is now being developed with increasing confidence and is certainly destined to produce increasingly brilliant results.

Acknowledgements

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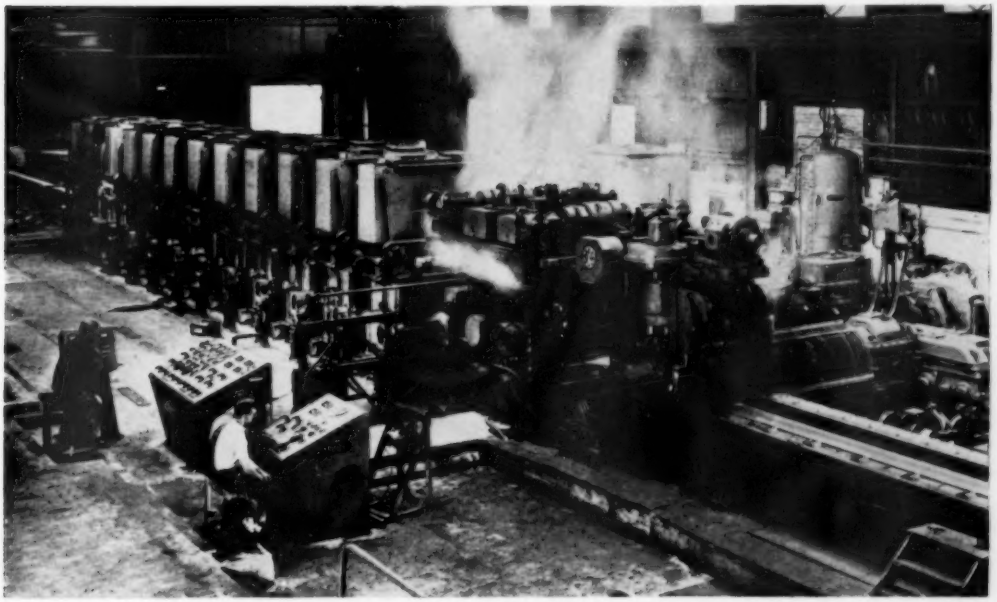
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Fig. 20.—One of the Sendzimir planetary hot mills installed in this country (shown below) is at the works of J. J. Habershon and Sons Ltd., a member of the Firth-Cleveland Group. This mill was the second of the four such installations known to be in operation at the present time. The layout is similar to that at SAFIM (cf. Fig. 1 (a)). A further planetary mill is installed in this country at Ductile Steels Ltd., and the Canadian installation is at Atlas Steels Ltd.



MANUFACTURING THE 'TRAV-O-LATOR' FOR THE BANK STATION, LONDON

Production Procedure at the Works of JAMES H. RANDALL and SON

AN interesting welding technique has recently been evolved by James H. Randall and Son Ltd., of Paddington Green, London, for the construction of over one thousand welded platforms forming part of the new Bank Station TRAV-O-LATORS. These "moving pavements," designed by the Otis Elevator Co. Ltd. and for whom Randalls, as sub-contractors, are manufacturing the platforms, are now being installed at the Bank Station of the Waterloo and City Railway which forms part of the Southern Region of British Railways. This installation is of a heavy railway design and will be the first of its type in Europe.

The Trav-O-Lators, are designed and constructed on similar principles to a normal escalator, operating an easier angle of incline, so that the series of moving platforms each 40 in. by 16 in., for a smooth inclined surface 300 ft. long, moving at a maximum speed of 2 m.p.h. on a 1-in-7 slope rather than a series of steps.

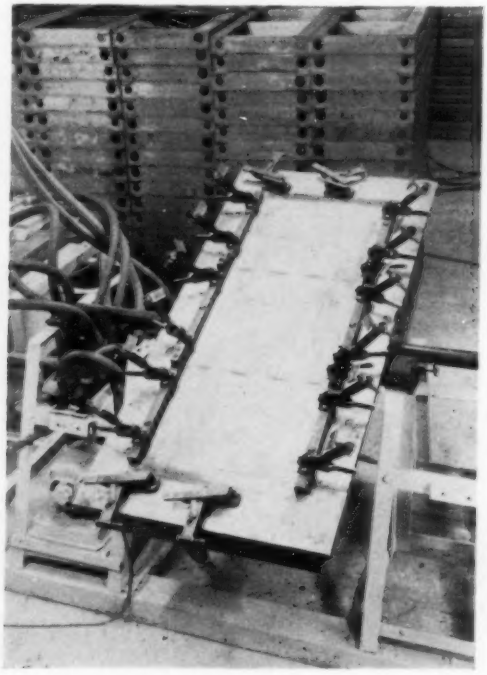
Two of these units are being installed side by side in a 16-ft. 6-in. diameter tunnel, and when in operation, towards the end of 1960, the 40,000 passengers who now clamber up and down the existing series of congested and awkward subway steps every day will be given a comfortable two-minute ride. The Trav-O-Lators are designed to operate in either direction.

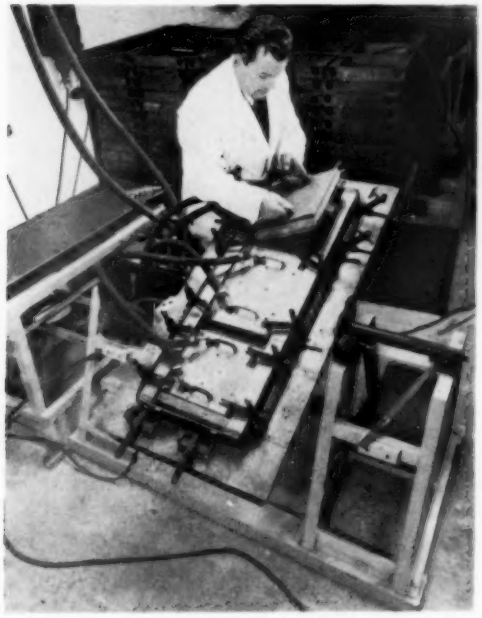
The Trav-O-Lator platforms, Fig. 1, are fabricated from $\frac{1}{16}$-in. steel plate, folded into a box

Fig. 1.—Platforms for the Trav-O-Lator as they will appear in use, showing, in the foreground, underside of a platform, and method of bolting treads



Fig. 2.—Fixture for welding platform end plates, showing clamps and pivot arrangement





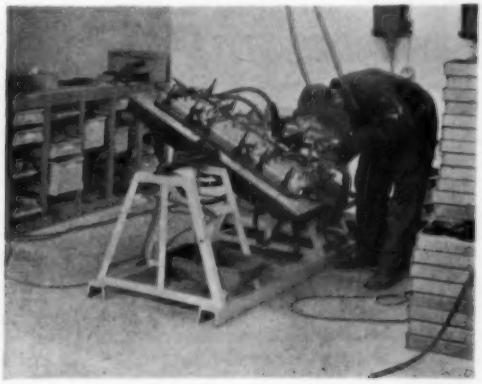


Fig. 4 (above).—General view of welding operations in progress

section with 2 ribs of $\frac{1}{16}$-in. plate and ends of $\frac{1}{4}$-in. bright steel plate welded on. Die-cast ribbed sectional treads are then bolted on to this platform unit.

An unusual degree of accuracy of manufacture is required in the production of these platforms. The specification demands a dimensional tolerance of 0.005 in. on the overall width of 44 in., and there is a 0.003-in. tolerance on the 25 holes which are punched in the platform in one operation before folding takes place. Two of these holes are used for locating purposes in every subsequent operation, including folding.

An essential requirement is that there is no distortion of the platforms due to the welding, so that when the die-cast aluminium treads are attached they form a perfectly flat surface. The bearing housings are welded to the platforms to support the axles which form part of the endless chains. A second fixed axle is welded into position to carry the trailer-wheels on which the platforms run. Here again freedom from distortion is of paramount importance. It was therefore necessary to design and construct a special fixture to hold the platform and its end plates during the welding

(*Continued in page* 518)

Fig. 3 (above).—Welding fixture, showing the three water-cooled copper tanks for heat dispersal being placed in position by Mr. N. Ford, works manager at Randalls, who designed the fixtures



Fig. 5 (right).—Jig for final inspection of finished Trav-O-Lator platform

Some Properties and Uses of

CLAD METALS

By A. C. GILBRAITH*

CLAD metals are laminates—combinations of two or more metals intimately joined together—to supply properties not found in any one of the metals of the composite. The most useful property of each metal is thus added to the most useful property of another. For example, where electrical conductivity coupled with high strength and magnetic properties is desired, copper clad on steel, or silver clad on steel, can be specified. It is apparent that any one of these two metals *alloyed* together, would not even remotely resemble the material resulting when they are laminated with each other.

Clad metals are made by a number of methods. Although more than 20 different processes are described in the literature here and abroad, only five systems are in general use today. These are: pressing, casting, direct rolling, sintering, and deposition. No matter which method is used, the result is a composite metal which cannot be separated by physical means short of complete destruction.

Clad metals can be drawn, rolled, spun, bent, twisted, heated, quenched, punched or otherwise formed, just like a solid metal. Many of the properties of clad metals can be predicted by the properties of their components before bonding. Strength and density, for example, are usually an arithmetical average of those values of the components. More complex calculations are required for such measurements as ductility, electrical conductivity and thermal conductivity.

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The corrosion-resistance characteristic of a clad metal is the same as that of the solid metal of which the surface is composed since the surface is solid, non-porous, and homogeneous. It is this important property of clad metals that has led to widespread use in the chemical processing industries.

Clad Metal Classifications

Clad metal combinations can be classified into four major categories: non-precious metal cladded to non-precious metal; precious metal cladded to non-precious metal; precious metal cladded to precious metal; and thermostat metals.

Some of the more common examples in these categories are—Non-precious to non-precious: phosphor-bronze-on-copper, stainless-steel-on-copper, brass-on-steel, copper-on-beryllium copper, copper-on-steel, nickel-on-steel. Precious to non-precious: silver-on-beryllium copper, silver-on-copper, gold-on-copper, gold-on-nickel, silver-on-Monel, silver-on-phosphor bronze, silver-on-steel. Precious to precious: palladium-on-silver, platinum-on-silver.

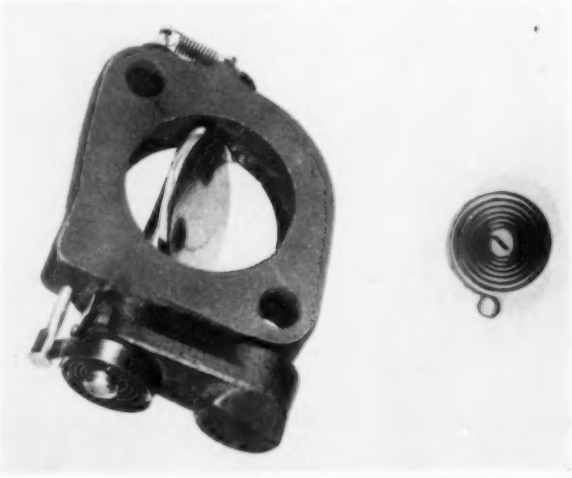


Fig. 1 (right).—Thermostat bimetals, which are constituents of thermostatic coils such as this one for the butterfly valve of an automotive exhaust manifold, are actually clad metals. One of the metals has a high, the other a low, coefficient of expansion

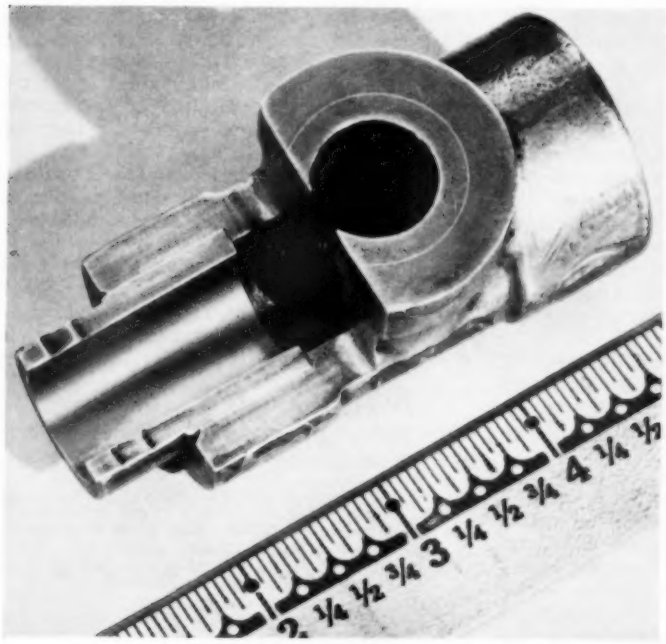


Fig. 2 (left).—A special type of clad metal overcomes many of the disadvantages associated with standard silver brazing practice. When silver brazing alloy is clad to ferrous or non-ferrous strip, it does not run on heating, and provides a braze which is continuous, uniform, and covers the entire joint area, typified by this hydrogen pressure valve joint, a cutaway area of which is shown

Fig. 3 (below).—In this battery-operated tape recorder the finger contact assemblies are fabricated from precision-rolled silver-clad phosphor-bronze. This cuts the amount of precious metal used and saves space. Clad metals are ideal for miniaturization applications

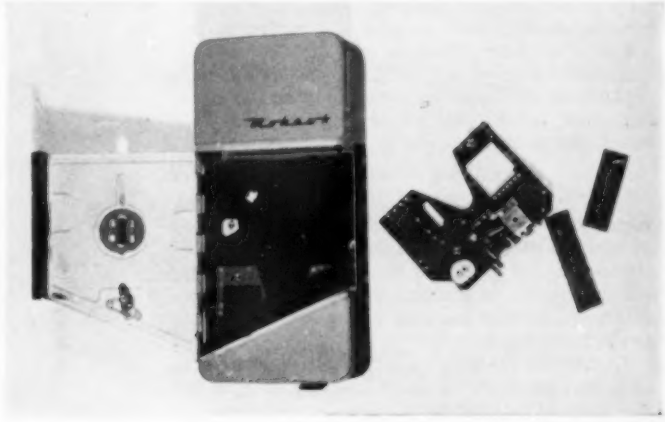
Reasons for Using Clad Metals

Clad metals are used for two basic reasons: to supply an unusual physical property requirement and to bring about cost savings.

For unusual physical properties clad metals can supply a unique combination of properties in one unit. Clad metal parts can be designed to take advantage of the best qualities of several metals. In this way, the engineer can meet the demands for corrosion-resistance plus greater strength, or corrosion-resistance plus excellent thermal conductivity, or oxidation-resistance plus thermostatic properties, or excellent bearing properties plus high strength.

An interesting example of the potential of these new materials is found where the specifications call for a set of properties that are not available in any one metal. An example of this can be shown by a current-carrying spring. Here, high tensile strength, ability to stand continuous flexure, surface hardness, high electrical conductivity, and ability to resist electric arcing are the requirements. Although this combination of properties cannot be found in any one metal, silver clad phosphor-bronze, or silver clad beryllium-copper will meet the requirements.

There are many other situations where it is impossible for any single metal to do the job adequately. A specific example of situations of this type in the design of such items as circuit breakers, electric irons, or automatic chokes—units which must be actuated as a result of



temperature changes. This problem can be solved by using a combination of two metals with different expansion characteristics, causing a deflection to take place as temperature rises.

One thermostat bimetal is composed of layers of equal thickness of Invar (36 per cent nickel-iron alloy) as the low-expansive lamina, and a nickel-chromium-iron alloy for the high-expansive component (nominal composition: 22 per cent nickel, 3 per cent chromium, the remainder iron). This general-purpose bimetal known in the trade as ASC-1, combines a high deflection rate over a high temperature range with high strength, high electrical resistivity, and a fair degree of corrosion resistance.

Thermostat metals are available commercially in a wide variety of shapes and forms—cantilever strips, U-shapes, spirals, helices, flat blades—suggesting successful applications in many design situations.

For possible cost savings—Here is a typical example of how clad metals effect economies. A chemical container needs corrosion resistance plus surface wearing qualities and nickel is specified. Nickel is costly and in short supply and investigation shows that nickel-clad steel can be used. In this case an extremely thin layer of the nickel will meet all of the engineering requirements and the use of steel will reduce costs.

Nickel-on-steel could solve the same problem in the electronic industry where, in the manufacture of cathode-ray tubes, nickel is needed only as a surface element. Other examples of savings in costs brought about by clad metals are found in the chemical and electrical industries. When specifications called for a material with good heat-conductivity or electrical-conductivity properties, copper was formerly used. Now, less expensive copper-clad steel can be employed.

Cost-savings through the use of clad metals is most important in the chemical industry where precious metals, such as gold and platinum, are required to meet corrosion resistance problems. The substitution of clad metals for the solid metals —platinum-on-copper for solid platinum and gold-on-copper (gold-filled) for solid gold—can effect significant savings.

Specifying Clad Metals

The type of cladding should be specified as metals can be cladded to each other in a number of ways. The nature of the cladding can help solve the mechanical aspects of the design requirements, and contribute to meeting the economic requirements. Clad metal strip is commercially available in the following forms :—

Overlay—a cladding on either one or both sides of a base metal in which the cladding extends the full width of the base metal.

Inlay—a cladding on either one or both sides of a base metal in which the cladding extends for only a portion of the width of the base metal.

Edgelay—a cladding on either one edge or the other of a base metal in which the cladding extends only a portion of the overall width and in the same thickness as the base metal.

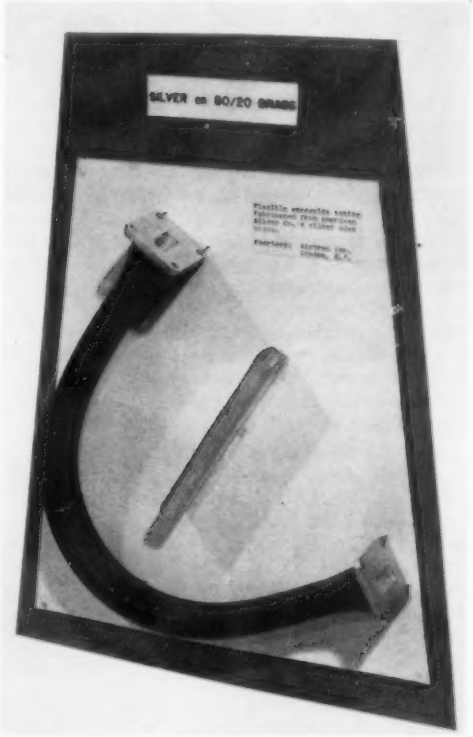
Thrulay—a cladding which extends only a portion of the overall width and in the same thickness as the base metal, and which extends through the body of the composite.

Thickness and width should also be specified. Manufacturers can now supply overlay in thicknesses down to 0.00002 in. and total overall thicknesses down to 0.001 in. Widths are available up to 4 in.

Design Functions of Clad Metals

The number of metals that can be clad to each other to produce new combinations of properties

Fig. 4.—Silver-clad brass is a money- and space-saver in this flexible wave guide tubing. Clad metals have resulted in vast economies in electronic manufacture. Where extreme precision is required they can be rolled to tolerances as close as ±0.0001 in.



is increasing. Clad metals can usually be made to meet a particular set of specifications. There are, however, many standard composites which are available. The following table lists the more important clad metals and a description of their design functions.

Clad Metals	*Design Functions*	*Applications*
Stainless Steel-on-Low-carbon Steel	Erosion-resistance. Corrosion-resistance. Base metal can be worked easily. Decoration. Base metal is low-cost.	Decorative trim. Cooking utensils. Process industries equipment. Hospital sterilizers. Food display cases.
Stainless Steel-on-Copper ..	Corrosion-resistance. Erosion-resistance. Thermal conductivity. Uniform heat transfer. Decoration. Workable base metal.	Heat exchangers for chemical industry. Pots and pans.
Copper-on-Low-carbon Steel	Thermal conductivity. Resistance to atmospheric gases. Surface compressibility. Excellent solder characteristics. Strong, inexpensive base.	Electrical contact points. Electrical switches. Immersion heater base plates.
Phosphor Bronze-on-Copper	Excellent spring properties. Base has high electrical conductivity.	Current-carrying springs. Flat spring blades for switches and electrical meters.
Nickel-on-Low-carbon Steel	Resistance to atmospheric gases. Decoration.	Broiler trays. Fan blades. Brush ferrules. Toys. Typewriter key levers.
Monel-on-Low-carbon Steel	Corrosion-resistance. Erosion-resistance. Uniform heat transfer. Low-cost base metal.	Equipment for chemical and other process industries.
Stainless Steel-on-Invar ..	Thermostat metals.	Thermostats. Circuit breakers.
Silver-on-Copper	Oxidation-resistance at high temperatures. Atmosphere resistance. Electrical conductivity. Low-cost base.	Coils (high temperature). Conductors (high frequency). Radar cable braiding.
Silver-on-Phosphor-Bronze ..	Electrical contact properties. Electrical conductivity. Good spring properties in base.	Electrical contact springs.
Silver-on-Beryllium-Copper Copper-on-Beryllium-Copper ..	Electrical contact properties. Electrical conductivity. Good spring properies in base. Good fatigue resistance in base.	Current-carrying springs.
Silver-on-Nickel	Good wear-resistance. Corrosion-resistance. Electrical contact properties.	Electrical contacts where corrosion-resistance and wear-resistance are important.
Gold-on-Copper	Chemical resistance. Low cost base.	Chemical processing equipment.
Gold-on-Nickel	Chemical-resistance. Low-cost base.	Chemical processing equipment. Jewellery wrist bands, watch cases.
Gold-on-Brass	Chemical-resistance. Low-cost base.	Chemical processing equipment. Jewellery wrist bands.

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Clad Metals

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Some Comparisons Between Clad and Electroplated Metals

It is sometimes more economical to use clad metals rather than electroplated metals because the perfect bond between clad metal layers eliminates rejects of fabricated parts due to cracks and peeling caused by faulty electroplate. The clad metal overlay will not peel off during heat treatment, soldering, or during any other processing.

The perfect mechanical bond between clad metal layers insures excellent thermal and electrical conductivity, whereas this may not always be so with electroplated metals. The clad metal overlay is hard, uniform, and dense because of the working given to the metal while an electroplate deposit is sometimes soft, non-uniform, and porous.

It has been found that a thin, dense, clad overlay offers greater resistance to corrosion, arcing, and pitting than a heavier electroplated deposit. Clad metal overlay thickness can be accurately predetermined. This is not always possible with an electroplate.

A specific design problem may be solved by a coating on just one side of a fabricated part; electroplating, usually involves plating all sides.

The temper and other physical properties of clad metals can usually be provided to meet the specifications required. The use of clad metals eliminates labour costs due to racking and preparation, as well as additional inspection.

Clad Metals Applications

Clad metals should be considered for use wherever a composite metal can do the job better and less expensively than any single metal. Currently clad metals are specified in the chemical, brewing, pulp and paper, textile, soap, food processing, automotive, hydraulic, petroleum, and electrical industries.

Clad metals are also being used for such thermal applications as heat-exchangers, preheaters, tanks and tank cars, dryers, stills, autoclaves, coagulators, saturators, extractors, disinfectors, cookers, ovens, and kettles. They are found in evaporators, vats, crystalizers, mixers, and table tops.

More applications are found in cooking utensils, automotive bumpers, coins, badges, medallions, mouldings, stair nosings, electric-motor parts, ball-bearing separators, gas meters, flexible and lock seam tubing, X-ray equipment, automotive engine parts, immersion heaters, electronic equipment, and gaskets.

Manufacturing the "Trav-O-Lator"

(*Continued from page* 513)

operation, so that the heat involved while making a 22-in. weld at each end of the platforms could be evenly dispersed without causing distortion.

This fixture, Fig. 2, consists of a surface plate which is pivoted to a fabricated frame so that it can be locked in convenient working positions. Toggle clamps attached to the surface plate hold the main platform sheet and its end plates in their appropriate positions.

To assist heat dispersal, three rectangular copper tanks, through which water is circulated *via* flexible hoses by an electrically driven pump, are clamped inside the platform before welding begins (Fig. 3), and in addition there are two smaller water-cooled tanks built into the underside of the surface plate immediately beneath the two main welds. This method of water cooling (making use of a Randall Aquasava water-cooling tower), together with the fact that the large mass of metal embodied in the surface plate absorbs and evens out any heat remaining, results in the quick and efficient production of distortion-free units.

Welding is carried out with a 12-gauge Philips No. 46 touch rod at a current of 100 amp. The welding set used is a Philips Industrial type E 1381 a.c. transformer with a current output of 15 to 200 amp.

The efficiency of the fixture, under production, is such that no dressing out is necessary after welding. Fig. 5 shows the treads bolted into position on the platform and final inspection of tolerances.

The finish of the platforms includes Bonderizing and a coat of black matt paint. The interior is sprayed with 3 lb. of "Aquaplas" to minimize noise due to drumming when in operation.

THE INSTITUTE OF METALS

Instructional Meeting for Younger Members

THE second of a series of instructional meetings for younger members will be held at Ashorne Hill, Leamington Spa between July 20 and 23, 1960. The topic for study at this meeting will be "The Design and Operation of Plant for Extrusion of Non-Ferrous Metals." The Directors of Studies are Mr. E. K. L. Haffner (Loewy Engineering Co. Ltd.) and Dr. N. Swindells (McKechnie Brothers Ltd.).

Persons attending the meeting will be required to reside at Ashorne Hill for the duration of the meeting. The meeting fee, inclusive of accommodation and meals, is £11.

BRITISH IRON AND STEEL RESEARCH ASSOCIATION

Some Extracts from the Annual Report, 1959

SHEET AND STRIP MANUFACTURE

Scale Removal

IT has been found that pickling mild-steel strip with a scale structure in which wüstite is in contact with the parent metal takes up to 40 per cent less time than pickling strip with the type of scale produced by many present-day mills; that is, scale with a magnetite layer in contact with the metal. The first of these structures has been found in cobbled strip and in some samples of strip finished at high temperature. Work on relating the scale structure to the thermal history of the strip is continuing, to ascertain whether the specified conditions of hot strip production for the formation of the most easily pickled scale can be met within the existing scope of metallurgical practice.

One of the problems in the design of scale-breakers is to find the best balance between the amount of work hardening of the strip and the degree of breaking of the scale. From initial laboratory experiments it would seem that there is an optimum angle of wrap for a given roller geometry and that above this the improvement in pickling speed is marginal compared to the amount of additional cold working of the strip. It was also found that the edges of the hot-rolled strip, both before and after the scale-breaking, pickled much more slowly than the centre. Since the speed of the strip through the pickling tanks is governed by the need to remove the slowest-pickling scale, the reasons for this abnormality of the edge scale are being sought.

Cold Rolling

A method of assessing cold-rolling lubricants prior to their full-scale industrial application has been developed on the 14-in. laboratory mill. The technique gives a realistic assessment of their probable behaviour on a production mill. A series of trials on one group of new rolling oils has shown that at high speeds their lubricity is better than that of a conventional soluble oil and has suggested that it might, in some circumstances, approach that of palm oil.

Work has been started on the boundary and hydrodynamic aspects of cold-rolling lubrication. Significant advances have been made in the understanding of the mechanism of lubrication. In particular, experiments have shown a clear-cut correlation between molecular chain length of the lubricant and the apparent coefficient of friction at low speeds. At high speeds, however, lubrication apparently depends on the bulk viscosity of the lubricant and the micro-surface-structure of the strip and rolls. These results have led to the development of a technique for improving lubrication in rolling by changing the configuration of the micro-irregularities of the roll surface.

Annealing

Earlier laboratory work on the continuous annealing cycle for blackplate has shown that it might be feasible to shorten the annealing cycle from about 3 min. to less than 10 sec. This has great significance in reducing the pass length of continuous annealing lines and thereby the capital and running costs.

Initially, it seemed necessary for the shortened cycle to be followed by an over-ageing treatment at 300° C. after coiling, and for this treatment a protective atmosphere is needed during and after cooling. However, further laboratory work has shown that a protective atmosphere is probably not necessary since, for a range of steel compositions, hardness values comparable with those achieved in commercial practice have been obtained with over-ageing below the minimum oxidizing temperature of the mild-steel strip.

As properties other than hardness are important in can-making, it is necessary to confirm the laboratory work by can-making trials. For this purpose a gas-fired annealing plant has been made in which 5-in. wide strip can be heated to 700° C. in about 6 sec. and then quenched in oil to the coiling temperature. A quantity of material is being prepared for assessment at a can manufacturers' works.

Work is also in progress on the development of a suitable fast annealing cycle for thicker gauges of mild-steel sheet and strip of moderate formability. To determine the optimum conditions for this cycle the effects of annealing temperature, grain size, sulphur content, and amount of cold work on the kinetics of recrystallization in mild-steel strip 0.025 in. thick are being investigated in the laboratory.

Tinning

A substantial increase in electrolytic-tinning-line plant capacity is planned by the industry for the next few years, and therefore a considerable effort has been applied to improvements in electrolytic-tinning practice.

One of the most important problems now receiving attention concerns the rust resistance of containers made with thin external coatings of tin. It is known that rust resistance is related to the amount of tin applied and to the roughness of the base steel, and previous BISRA laboratory work showed that it was possible to smooth the steel by an electrolytic method which preferentially dissolves the micro-peaks. This reduces the surface area by between 30 and 40 per cent in an optimum time of about 1 sec.

The laboratory work has been followed up by tinning runs at 100 ft. per min. on the experimental processing line, and it has been found that, in spite of the movement of the strip through the tank, the smoothing action still occurs to the same degree as in the laboratory experiments. It has also been found that the smoothing electrolyte is quite as effective as sulphuric acid in etching. A batch of material is being prepared on the processing line for assessment by the metal container manufacturers, and process trials are being planned with the tinplate manufacturers.

Development of the "Iron Flash" method of identifying differentially coated tinplate has continued. The method, which involves electrodepositing a thin layer of iron on one surface of the tinplate before flow brightening, has been successfully tried out on the experimental electrolytic processing line. Work is now proceeding to confirm that the iron does not adversely affect the properties of the finished product, and material is being processed on the experimental line for assessment by the tinplate users.

The prospective use of tinplate in coil form emphasizes the need for a surface inspection instrument to be used in line. Work has continued in the Physics Department on the design of a suitable instrument, and progress is reported. This work has been supported by an investigation of current practice in the inspection of tinplate.

Plastic-coated Steel

Two of the licensees of the Plasteel process are now in production, one manufacturing wide strip and the other narrow strip. Further licence arrangements are pending. A working group comprising representatives from manufacturers of plastic-coated steel and other interested parties has been formed to advise on promising fields for further development.

On an experimental plant, a method has been developed by which films of low plasticizer content can be produced with a quality equal to that of calendered film. More recently attention has been concentrated on evolving a suitable method of applying a thin coating of pvc to strip at high speed. A method of "direct calendering" of powders is being evolved, which is not subject to the speed limitation which exists for plastisols. The process involves spreading a pvc powder on to heated strip and then consolidating in a roll nip. Among the potential uses for the low-cost product is the manufacture of medium-sized containers.

Electrophoretic Deposition of Aluminium

Earlier work on the use of electrophoresis for the deposition of ground resins from a suspension suggested that the method could be used for applying finely ground aluminium powder to sheet and strip. It was found that a uniform deposit of the powder could readily be made but there were problems in making the aluminium adhere as a coherent layer. The work is in its early stages, but if the difficulties can be overcome it will make available a process for applying a wide range of aluminium coatings with low-alloy content. At the present time the product is adequate for providing a base for vitreous enamelling in such applications as the infill panels of buildings, and some progress has been made in developing the process for this application.

Lacquered Strip

The main problem in providing a high-speed lacquering process for strip is the long curing time of the lacquers available at present. Apart from work, in conjunction with the manufacturers, aimed at finding a suitable fast-curing lacquer, research has been directed to electrophoretic deposition of partially cured lacquers so as to avoid long curing cycles. With epoxy-polyamide resin emulsions it seems that high rates of deposition are possible, but the use of the more common epoxy-phenolic type has been held up by the lack of a resin ground to a sufficiently smooth fineness. One manufacturer has, however, recently succeeded in grinding such a resin satisfactorily so that this work can now be pursued.

In anticipation of the need for faster lacquering once the problem of curing has been overcome, curtain coating techniques have been investigated. Results indicate that a stable curtain of lacquer can be achieved, and though the precise flow rate limits have not yet been defined, it seems that curtain coatings would allow operation at line speeds in excess of 500 to 600 ft. per min. for a coating 0.0001 in. thick.

PLANT ENGINEERING AND ENERGY DIVISION

Rolling-Mill Plant

Automatic Gauge Control

A hydro-mechanical system incorporating the dual capsule (the BISRA Dyna-modulator) tested previously on the 14-in. experimental mill is under test in the Battersea Laboratory. If successful it will provide a self-contained gauge-control unit which will respond faster than existing systems. A capsule is placed between the screw and the top chock on each side of the mill; the capsule responds to changes in the roll gap, and the movement of the

capsule platen is used to operate a hydraulic control valve through an adjustable lever system. Compensation for the deformation of the mill components under load is achieved by a pressure transducer which gives a mechanical output proportional to the load and re-sets the linkage to the control valve. The valve controls the flow of oil into or out of the modulating chamber of a capsule in such a way as to keep the roll gap constant.

An aircraft company has co-operated in this project by carrying out static simulation tests on a special rig with one of its own control valves. A modified version of this valve is being supplied as an alternative to one designed by BISRA. The system for one side of the mill is being tested in a 100-ton hydraulic press which has about the same stiffness as the 14-in. experimental mill at Sheffield and is controlled to stimulate variations in the roll gap of a mill. On satisfactory completion of these tests, a second capsule will be constructed and both used for trials on the mill at Sheffield. An alternative electro-hydraulic system is being developed by the Physics Department.

Primary Mill Automation

With the object of demonstrating that the auxiliary drives on an existing primary mill can be automatically controlled, work has been carried out on the screwdown of a rolling mill at a large steelworks. The requirements have changed considerably as experience has been gained and the final scheme embodies a unit which stores four rolling programmes, each operated by a "next pass" button. Roll position is detected by potential dividers operating from a 400-c/s supply with electronic and metadyne amplification stages.

Early tests revealed instability, and a combined theoretical and practical investigation yielded enough data to enable the system to be simulated approximately on an analogue simulator. As a result, it was possible to predict what steps were necessary to stabilize the screwdown drive. These steps were duly taken at the steelworks, with the result that eight 9-ton ingots were rolled without incident.

New Engineering Techniques

Automatic Control

In the laboratory a 50-h.p. mill-type motor has been equipped with a heavy-duty variable backlash coupling which is installed between two 100-h.p. 4½:1 gear boxes arranged back to back, and the effect of backlash on accuracy of position control of the complete drive will be investigated.

A second 50-h.p. mill-type motor has been used to investigate digital position control. Injecting a signal of 3 decimal digits into the system starts up the motor, which stops again only after it has generated the 4-digit number of pulses by means of a pulse generator coupled to it. The present arrangement stops the motor with an accuracy of one-eighth of a revolution, or 1 part in 10,000, over the whole range of the motor movement. Tests with this equipment have confirmed that anticipatory deceleration is essential, and a suitable feed-back circuit is being designed.

Motor Control

The present method of motor control, using mercury-arc rectifiers, relies on allowing the rectifiers to conduct current for a controlled portion of each half cycle. At low voltages this causes undesirable disturbances in the mains supply. A new method of control under development aims to control the power supply to motors by either using or not using nearly complete half-cycles of the supply, the half-cycles used being chosen to give the required output with the least possible disturbance to mains current.

A pulse pattern generator has been built to control the sequence of firing of converter grids. Preliminary experiments were carried out on a small motor and preparations are now being made to control a 50-h.p. motor by this means and to determine the best firing patterns to use. It has also been found possible, by controlling the firing of the grids of a mercury-arc rectifier, to produce an a.c. output of approximately sinusoidal wave form at 16⅔ c/s from the six-phase supply.

Trials have been completed on another method of motor control which wastes less electricity than conventional series-resistance starting circuits. A transformer has two secondary windings with output voltages in the ratio of 3 to 1 and these are used together as well as single to give, after rectification, 4 equal d.c. voltage steps in either direction. These are applied to the motor *via* a push-button arrangement or a conventional master controller to give 4 steps of speed in either direction.

PHYSICS DEPARTMENT

Instruments

Continuous Inspection of Tinplate

The aim here is to develop an objective means of continuous in-line assessment of the surface quality of electrolytic tinplate, as this will be necessary in the future for tinplate sold in coils. An investigation of the way in which prime and defective tinplate reflect light, led to the development of a multi-cell instrument for measuring the diffuse reflection from the plate, as this increases greatly when a defect is present. No optical scanning is used; each fixed photo-cell unit covers a strip on the moving tinplate small enough for the diffused light from a defect to produce a signal which recognizably exceeds the normal variations in reflection from prime material. The signal can be "gated" so that only pulses exceeding the value considered significant are transmitted for counting or other means of assessment. The first

model of this instrument covers a 12-in. width of strip with ten photocell units. It is thus a third of the size required for the usual sheet width but is large enough to try out the multi-cell method of fault detection at a strip speed of 1,000 ft. per min.

The signal waveforms produced by a variety of common defects have been studied and methods worked out for grading the signals in terms of severity of defect. It is now necessary to develop methods of sampling or collating the defect signals so that it will be possible to decide whether a section of tinplate is prime or defective.

Automatic Control of Strip Gauge

In order that the BISRA Dyna-modulator system for hydraulic modulation of roll force may be used in conjunction with the BISRA gaugemeter to give automatic gauge control, it is necessary to devise suitable transducers to convert the hydraulic pressures and piston displacement in the Dyna-modulator into electrical signals. Suitable pressure/electrical transducers have been procured and a method of producing an electrical signal proportional to the flow of fluid in or out of the Dyna-modulator chamber, and so to the piston displacement, has been developed. This apparatus is now being assembled for tests with the Plant Engineering and Energy Division's experimental Dyna-modulator as a fast-acting electro-hydraulic a.g.c. system.

The manufacture of the Narrow Strip Width Meter developed by the Section some time ago has been undertaken by Davy and United Ltd., and a first model has been completed for a member firm.

End of Coil Control

It appears that a significant amount of plant time is lost in many steel strip processing lines because the operator is not certain when the end of a coil is going to emerge from the uncoiler, and so slows down the line unnecessarily early. This happens when stopping a coil end under a shear or welder to join it to another end, for example on cleaning lines and electrolytic tinning lines, and in cold mills which are slowed down for a weld in a built-up coil.

The Section has evolved a scheme by which a suitable (visible) mark can be applied to the strip, during a previous process, a specified distance from the coil end. This mark triggers a position control which either stops the line or slows it down to a specific speed, so that the strip travels a specific distance and then either stops or slows down to a preset speed.

Temper-mill Control

There is, as yet, no satisfactory non-contact method of measuring the percentage elongation of strip to temper rolling, and one is needed if the temper-rolling process is to be properly controlled.

A new non-contact technique for measurement of the speed of a moving strip is being developed; by using it to compare the input and output speeds it will be possible to calculate the percentage reduction. The strip surface is illuminated with two spots of light (images of a lamp filament) arranged to about 6 in. apart and in line with the direction of motion of the strip, so that one spot is directly downstream of the other. Two photocells are arranged to view separately the light reflected from the surface at these spots. As the strip passes, variations in its surface cause variations in the reflected light intensity, and since the same portion of surface passes the two filament images in turn, the light signals received by the two photocells are the same apart from a delay in time. The earlier signal is delayed on a tape recorder, or on a rotating magnetic drum, and the two signals are then correlated; the delay is adjusted until the correlation is a maximum. The strip speed is then known from the delay and the distance between the images. By placing two pairs of light sources, one in front of and one after the temper mill, the two delays can be compared and the reduction of thickness obtained. Accuracies of better than 1 part in 400 are expected.

A demonstration of this technique was given at the BISRA Open Days, using a commercial tape recorder with a band width of only 10 kc/s. In this apparatus the correlation indicator was sensitive to a change in the delay, and hence of speed, of 1 part in 800. An experimental apparatus suitable for testing on a 1,250 ft. per min. temper mill is being developed. This will incorporate a servo to keep the correlation function at its maximum; by automatically adjusting the delay it will thus give a continuous reading of speeds.

Automatic Gauge Control of Tandem Mills

Although considerable progress has been made in the development of continuous strip gauge measurement and in the application of automatic gauge control to single stand mills, there are still many problems in applying a.g.c. to tandem strip mills. Because of the interaction between stands, theoretical analysis of the behaviour of the system with various forms of feedback control is complicated; furthermore the "constants" of the mill stands are not yet well known; there is as yet no basis for design of an optimum control system.

Recent work by the Automation Section has shown that by applying matrix theory to the fundamental equations of motion for a stand and mill some useful predictions can be made of the behaviour of various control systems applied to the mill. However, before much progress can be made in designing an optimum control system for a specific tandem mill it is essential to know the values of the coefficients in the linearized equations of motion. Experiments have been designed to determine these coefficients on a production 4-stand mill with the co-operation of the Steel

(*Continued in page* 534)

An Investigation into the

USE OF THE SWIFT CUPPING TEST FOR THE ASSESSMENT OF STEEL SHEET FOR COLD PRESSING*

And a Comparison of this Test, Using a Hemi-ellipsoidal Punch, with the Olsen Test

By ROGER PEARCE, B.A., B.Sc. (Oxon)†

(A communication from the British Deep Drawing Research Group)

Introduction

FOR some years, it was thought that a simulative test for the assessment of sheet metal for cold pressing was required. For this reason, the Swift Cup Forming Test was developed and this has been tested by various workers with different results. This report contains the results of the work described in the title of this paper and seeks to present a picture of the cupping test and the difference between stretching and drawing tests.

A major cause of splitting and the production of imperfect pressings is the use of rimming steel, which has been allowed to age, for their manufacture. Ageing in rimming steel can be first observed as a kink at the yield point on the load-elongation curve and next by a rise in the yield point, which can be of the order of 4 tons per sq. in. for fully aged material.

It was decided to investigate the ability of the Swift Cup-Forming Test to differentiate between steel in the aged and unaged conditions, and to continue from this to compare this test with the Olsen Cupping Test.

Material

The steel used for the first work was open-hearth rimming steel. Several large sheets with different batch numbers were used, but a given series of tests were all taken from one sheet as indicated. In the work on the Olsen test, rimming steel from various mills was used.

Experimental Methods

The Swift Cup-Forming test was carried out in the manner prescribed by B.I.S.R.A.[1] and the tensile test as described in a previous paper[2].

The Olsen Test was performed on a blank approximately 4 in. square and lubricated with

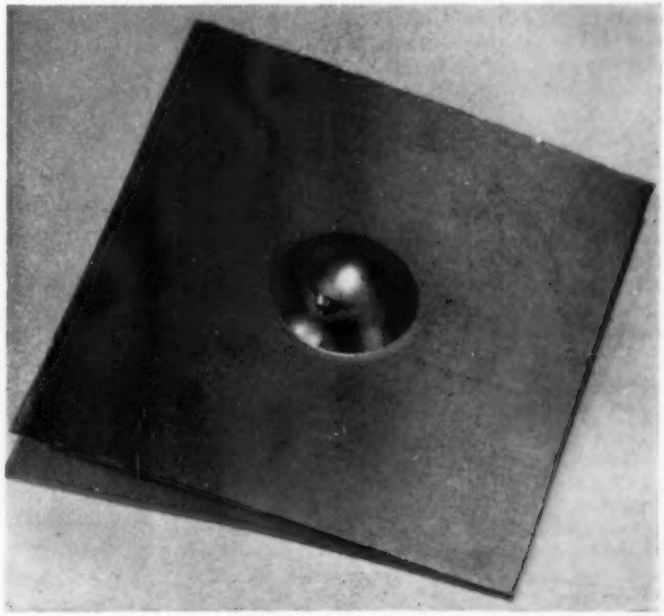


Fig. 1.—Olsen test

* This paper was made available to the delegates at the recent International Deep Drawing Research Group meeting in Paris.

† Pressed Steel Co. Ltd.

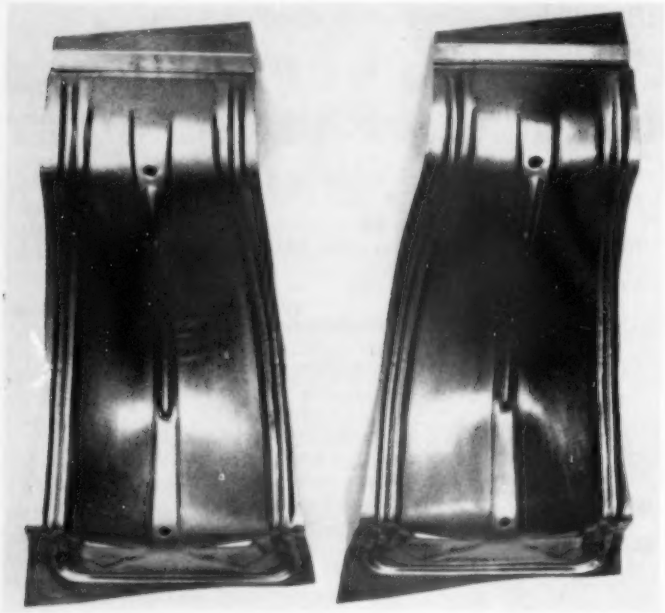


Fig. 2 (left).—Pressings in RVN steel in the fresh and aged condition

Fig. 3 (below).—RVN steel pressing : fresh steel

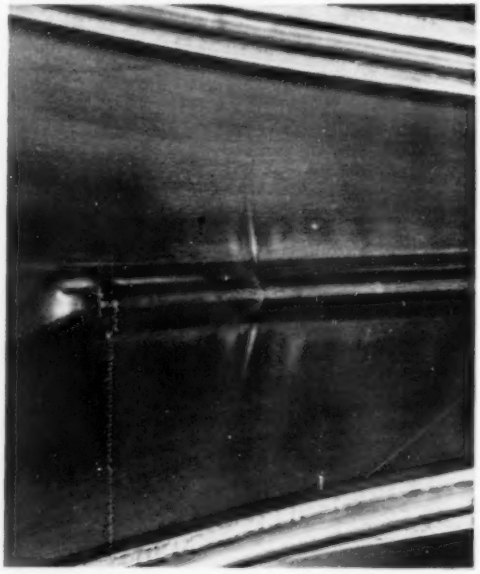
oil used for the cup-forming test on the side of the blank in contact with the ball. The ball was motor-operated until near the end of the test and then the last part until fracture was carried out by hand. Fracture is indicated by oil appearing on the outside of the blank (Fig. 1) and this was regarded as the end-point of the test. Ageing in this report was artificial ageing, which consisted of holding the steel at 100° C. for one hour.

Test Rating

The depth of the cup drawn in sheet metal is described by a dimensionless number termed the Drawing Ratio and represented by the neutral symbol β which is calculated by dividing the blank diameter by the punch diameter. The Limiting Drawing Ratio, represented by β_c, is the nominal maximum blank diameter divided by the punch diameter.

Results with Aged and Non-aged Rimming Steel (at standard Blankholder Pressure of 50 lb. per sq. in.)

Actual pressings made from the sheet steel designated RVN, in the fresh and in the aged condition, are shown in Figs. 2, 3 and 4. Fig. 2 gives a general view of both pressings. The increase in the buckling with aged material is evident, and seen even more clearly in Figs. 3 and 4. Attempts to remove this buckle by increasing pressure on the upper blank-holder of the press merely gave split panels. This is a typical example of the sort of trouble experienced with irregular shaped pressed motor-car panels, where making the correct shape is quite difficult, but the production of a



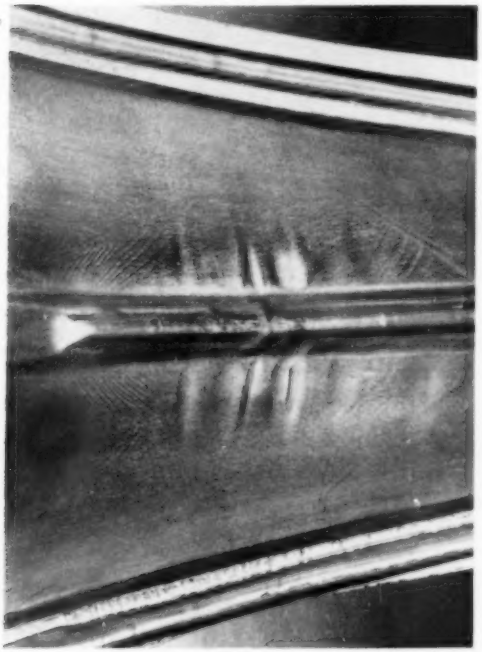


Fig. 4.—RVN steel pressing ; aged steel

split-free pressing is comparatively easy. The experimental results of these tests are given in Table I. This shows that, on ageing, the yield point rises from 12.5 tons per sq. in. to about 16 tons per sq. in., while the L.D. Ratios for both the hemispherical and flat-bottomed punches remain the same. Table II confirms the results given in Table I for five other different heat numbers of rimming steel. It is interesting to note that the L.D. Ratio never falls after ageing, either for the hemispherical or the flat-bottomed cup. It will be noticed in some cases that the L.D. Ratios increase after ageing.

TABLE I—RVN

		Non-aged	Aged
Yield point	L	12.3	16.0
	T	12.5	15.5
Ultimate tensile strength	L	21.0	21.2
	T	21.2	21.3
2-in. elongation	L	46.5	41.0
	T	44.5	44.0
8-in. elongation	L	33.3	29.5
	T	30.5	29.7
General elongation ..	L	29.0	25.7
	T	25.8	25.0
Y.P./U.S.	L	58.7	72.5
	T	62.6	75.4
L.D.R. (hemispherical)		2.200	2.200
L.D.R. (flat)		2.125	2.125

Results with Aged and Non-aged Rimming Steel (at various blank-holder pressures)

As is demonstrated above, yield point is a very important property as far as producing a buckle-free pressing is concerned. Any simulative test, therefore, which is not sensitive to yield point is probably not of much use for assessing sheet metal for cold pressing.

Professor Swift's work[3] showed that the hemispherical punch was sensitive to yield point, but the present work shows that it is not as sensitive as a press in a production press shop to the small changes in yield point brought about by ageing.

TABLE II

	Yield point, tons per sq. in.		U.T.S., tons per sq. in.		2-in. elongation (per cent)		8-in. elongation (per cent)		Y.P./U.S. (per cent)		General elongation		L.D. Ratio hemi-spherical	L.D. Ratio flat
	L	T	L	T	L	T	L	T	L	T	L	T		
XTN														
As received	13.1	—	20.6	—	43.0	—	29.0	—	63.9	—	24.0	—	2.300	2.200
Aged ..	17.0	—	21.1	—	40.5	—	21.1	—	80.5	—	25.2	—	2.300	2.200
FUN														
As received	12.0	12.4	20.2	20.5	43.5	47.0	26.1	30.4	59.5	60.4	20.3	24.8	2.275	2.175
Aged ..	15.1	15.7	20.7	21.0	45.0	44.0	28.0	26.0	72.9	74.6	22.3	20.0	2.300	2.200
HUN														
As received	13.9	14.9	20.5	20.6	45.0	47.0	28.1	27.9	67.6	72.3	22.5	21.5	2.250	2.150
Aged ..	17.9	18.5	21.3	21.0	45.0	44.0	27.8	24.3	84.4	88.0	22.0	17.7	2.250	2.175
KUN														
As received	10.7	11.35	19.3	19.5	48.0	52.0	30.0	35.8	55.5	58.1	24.0	30.3	2.300	2.200
Aged ..	14.7	15.1	19.9	20.4	47.5	46.5	27.8	30.0	73.6	74.2	21.2	24.5	2.300	2.200
MUN														
As received	13.6	14.8	20.2	20.2	45.0	46.0	27.9	28.3	67.5	73.0	22.2	22.3	2.275	2.200
Aged ..	15.5	16.3	20.6	20.6	43.0	42.5	27.3	26.9	75.5	79.3	22.0	21.7	2.325	2.200

TABLE III—*Mechanical Properties and L.D. Ratios using Aged and Unaged Rimming Steel at Different Blank-holder Pressures*

Mechanical properties	Unaged L	Unaged T	Aged L	Aged T	L.D. Ratio at different blank-holder pressures: Blank-holder pressure	L.D. Ratio Unaged	L.D. Ratio Aged
Hemispherical punch							
Y.P., tons per sq. in.	12.3	12.5	16.0	15.5	20	—	2.200*
U.T.S., tons per sq. in.	21.0	21.2	21.2	21.3	25	2.225	2.200*
E 2-in. per cent	46.5	44.5	41.0	44.0	30	2.225	2.200
E 8-in. per cent	33.4	30.5	29.5	29.7	35	2.225	2.200
G.E., per cent	29.0	25.8	25.7	25.0	40	2.225	2.200
YP/US, per cent	58.7	62.6	75.4	72.5	50	2.200	2.200
					60	2.200	2.200
					65	2.200	2.175
					70	2.175	2.175
					75	2.175	2.175
					80	2.175	2.175
					85	2.175	2.175
Flat punch							
Y.P., tons per sq. in.	14.4	15.0	18.4	18.9	25	—	2.175*
U.T.S. tons per sq. in.	21.4	21.8	21.7	22.2	30	2.150	2.175
E 2-in., per cent	46.5	46.5	44.0	40.5	35	—	2.175
E 8-in., per cent	32.2	30.8	32.3	29.1	40	2.150	2.150
G.E., per cent	27.5	25.7	28.3	25.3	50	2.150	2.150
YP/US, per cent	67.2	70.2	84.5	84.8	60	2.150	2.150
					70	2.125	2.150
					75	—	2.150
					80	2.125	2.125
					85	2.125	2.125

* Denotes very slight wrinkling.

To try to overcome this defect, it was decided to try the effect of varying the blank-holder pressure to see whether this would differentiate between the aged and non-aged steel. All tests were carried out using a single sheet of rimming steel.

The results are shown in Table III. It will be seen that the yield point again rises about 3 tons per sq. in. on full ageing. Blank-holder pressures were varied between 20 and 85 lb. per sq. in., and the hemispherical punch was used, but it was found that below 30 lb. per sq. in. wrinkling could be observed on the finished cup and, therefore, the minimum pressure which could be used was, in fact, 30 lb. per sq. in. At this figure a difference of one L.D. Ratio was observed between aged and unaged material and this was maintained up to 40 lb. per sq. in. blank-holder pressure. Above that, apart from a slight anomaly at 65 lb. per sq. in., the L.D. Ratios are the same up to 85 lb. per sq. in. Using the flat-bottomed punch, as might have been expected, no particular significance can be attached to the figures. It seems, therefore, that by reducing blank-holder pressure from 50-30lb. per sq. in. a small difference between aged and non-aged material can be shown, but only in the case of the hemispherical punch. In the case of the flat-bottomed punch at 30 lb. per sq. in. aged material draws a deeper cup.

Results Using a Hemi-ellipsoidal Punch

This contour of punch was decided upon because it seemed that a more "pointed" punch might differentiate between fresh and aged steel more clearly, and an ellipsoid can be mathematically defined and needs no "blending-in" where the parallel part of the punch begins and the curved part ends. The ellipsoid used was chosen arbitrarily with a major axis of 3 in. and a minor axis of 2 in. The punch was a composite one with a base suitable for screwing into the press and the working part machined separately. This simplifies the manufacture of punches of different contour. The base is made from 1 per cent carbon steel in the annealed condition, while the working part is of B.S.S. 970, En. 32, machined in the annealed condition.

The punch was machined to size and then carburized and hardened from a salt bath. This gave practically no distortion or scaling, and polishing up with successively finer grades of emery paper to give a good finish before use did not change the shape of the punch, as far as checking with a template could determine.

The punch head and shank are shown in Figs. 5 and 6. L.D. Ratios for all three punch shapes, using aged and non-aged steel, together with the mechanical properties, are given in Table IV.

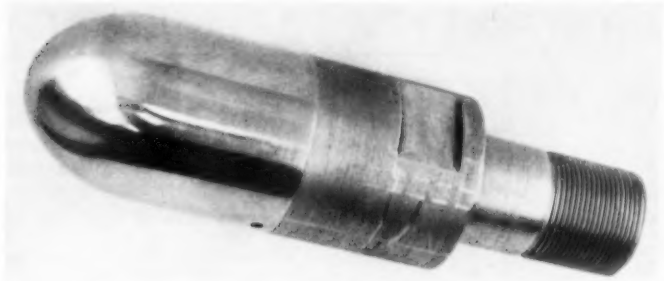
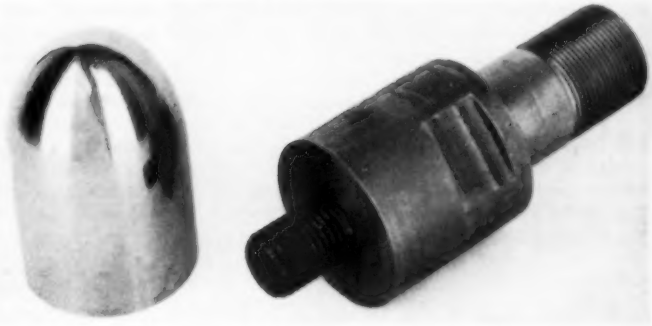


Fig. 5 (left).—Complete hemi-ellipsoidal punch head and shank

Fig. 6 (below).—Component parts of Fig. 5



It will be noticed that the ellipsoidal punch does differentiate between aged and non-aged steel to a larger extent than either of the other two punches so far used in the Swift Cup-Forming test. In Table II using a different batch of steel from the present one, it is shown that, using the hemispherical punch at 30 lb. per sq. in. blank-holder pressure, one L.D. Ratio is the difference between aged and non-aged steel. Using the ellipsoidal punch, however, three L.D. Ratios difference is found.

TABLE IV—*Mechanical Properties and L.D. Ratios with Aged and Unaged Rimming Steel using Flat, Hemispherical and Ellipsoidal Punches at 30 lb. Blank-holder Pressure*

	Unaged		Aged	
	L	T	L	T
Yield point, tons per sq. in.	14.7	16.6	18.5	19.2
Ultimate tensile strength, tons per sq. in.	22.2	22.8	22.4	23.4
Elongation 2 in., per cent	45.0	45.0	44.0	36.0
Elongation 8 in., per cent	29.5	28.0	25.0	24.0
General elongation, per cent	24.3	24.0	18.1	20.0
Y.P./U.S., per cent ..	66.5	72.8	82.4	82.0
L.D. Ratio flat	2.175		2.175	
L.D. Ratio hemispherical	2.200		2.200	
L.D. Ratio ellipsoidal ..	1.975		1.900	

Comparison Between Hemi-ellipsoidal Punch and the Olsen Cupping Test

In this experiment, 60 sheets of rimming steel on which routine tensile tests were requested by the press shop, were also submitted to the Swift Cup-Forming test, using the ellipsoidal punch and the Olsen Cupping test.

The L.D. Ratio is plotted against the Olsen value and the results are shown in Fig. 7. A distribution curve, Fig. 8, shows a degree of correlation between the Olsen value and L.D. Ratio.

Discussion

The inability of the Swift Cup-forming test to assess the effect of the finer points due to ageing, to the same degree as a press in a motor-car-body press shop, casts some doubt on its usefulness in assessing metal for these sensitive pressing operations, but when the blank-holder pressure is reduced from 50 to 30 lb. per sq. in. a small difference between aged and non-aged steel can be shown, but only in the case of the hemispherical punch. The flat punch can be ignored as a method of assessing steel for this type of pressing in which subtlety of shape is more important than splitting or depth of draw. This type of pressing is common in a motor-car-body press shop.

However, the difference shown up by the hemispherical punch at 30 lb. per sq. in. is only one L.D. Ratio and this is of small magnitude compared with the change in mechanical properties, especially yield point and the very substantial effects it can produce in the press shop.

The ellipsoidal punch, does in fact differentiate between steel in the aged and unaged conditions to a larger extent than any other punch tested. The results in Table IV show that at 30 lb. blank-holder pressure, no difference is detectable when using the hemispherical punch, but using the ellipsoidal punch, three L.D. Ratios difference is found.

In a cup-drawing test of this sort, as the punch becomes more pointed, more stretching of the

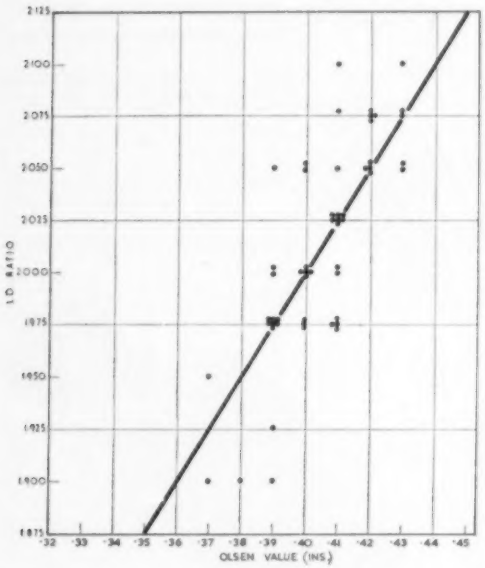


Fig. 7 (left).—Graph of L.D. Ratio against Olsen value

metal occurs prior to the drawing-in of the rest of the blank through the die ring. With the flat-bottomed punch stretching ceases immediately the radius on the edge of the punch is made, and drawing begins at an early stage. With a flat-bottomed punch with a very small radius on the corner, the amount of stretching would be exceedingly small. However, as the radius gradually increases, first the normal flat-bottomed cup is obtained, then the hemispherical cup and then the ellipsoidal one.

As the ratio of major to minor axis increases the amount of stretching which the metal receives over the head of the punch would increase because of the increased area of the hemi-ellipsoid over the hemisphere. The relative figures are given in Table V.

TABLE V

	Major axis, in.	Minor axis, in.	Area of Semi-ellipsoid, sq. in.
Hemispherical punch	2	2	6.28
Ellipsoidal punch	3	2	7.95

Thus, the area of the punch over which stretch has taken place in the preliminary stages of the operation before drawing-in really starts is 26.5 per cent greater in the case of the ellipsoidal punch than that of the hemispherical.

Another factor involved is the stressing of the blank itself. The load in lb. per sq. in., when the ellipsoidal punch first touches the blank is greater than in the case of the hemispherical punch and, therefore, causes more severe stretching of the material. This is shown by the low L.D. Ratios obtained.

The comparison between the Swift test using the ellipsoidal punch and the Olsen test is very interesting and Figs. 7 and 8 show that there is certainly a degree of correlation between these two tests. The Olsen test is rather sensitive to thickness of material and to allow for this as far as possible, the results were rounded to two decimal places. The thickness of the sheets used varied from 0.034 to 0.042 in. and it is felt that if work could be done using only one thickness of steel correlation would be better.

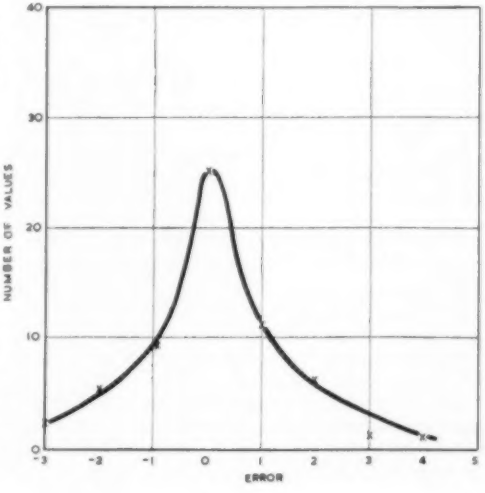
Conclusions

It seems that the Swift test using the ellipsoidal punch gives results comparable with the Olsen test. If the major axis of the ellipse were increased it is possible that the test will approximate more closely still to the Olsen test, as less drawing and more stretching should take place. If the major axis is decreased, then the differentiation between aged and non-aged rimming steel becomes increasingly less, until, when a hemispherical punch is used, no significant differentiation is made.

It can also be deduced that, as the Olsen test correlates with the Swift test using an ellipsoidal

(*Continued in page* 534)

Fig. 8.—Graph of number of values against error



AUTOMATED LINE PRODUCES 125 WASHER CABINETS PER HOUR

A Description of Plant and Procedure at PHILCO CORP., NASHVILLE, U.S.A.

By H. W. SHULZE*

PHILCO CORPORATION'S line of washing machines, including its Duomatic combination washer-dryer, are among the Philco appliances produced under contract at Nashville, Tenn. Included in the line is the Automagic washer that employs a special form of agitator, turning about a vertical axis and producing high-frequency washing action. This machine is top loading.

Also produced is a combination unit having a fixed cylinder set with its axis horizontal. Inside this cylinder is a rotating coaxial perforated basket in which washing and subsequent drying take place. This machine has a circular front door that serves for loading and unloading.

Cabinet Sizes Standardized

Both machines are designed to use the same basic rectangular four-walled cabinet. It is 34 in. high, 26⅜ in. wide and 26¼ in. deep (front to back), but openings in the front and rear faces are not the same because of the different operation and internal design. There is, of course, no circular front door in the unit designed for vertical agitator washing, and rear openings of the two cabinets differ to suit their respective functions.

* Manager, Laundry Operations, Philco Corporation.



Fig. 1.—Control station beside an elevated runway from which the operator can see and control the entire automated line

Because both basic cabinets are the same size, and are made from the same blank that is formed initially in the same way, total volume requirements are high and justify a well-automated production line. This includes a large hydraulic blanking press, a combination tangent bender and seam welder, an expander, and a row of supplementary special presses that do piercing and some secondary orming (*see* Fig. 2).

All of these units are so fully automated that no manual handling is needed. Although used for cabinets of both designs, some dies are made so that they work on one type of cabinet and some on the other type. Dies that operate for only one design of cabinet remain idle when the other design is run.

Once the total set-up has been made, it remains unchanged except for alteration in controls. They make possible a production shift from one form of cabinet to the other with almost no delay, because all die components remain in place.

A given run may continue for an hour or two, or as long as may be needed, on one type of cabinet. Then a shift to the other type is effected in a matter of seconds by the push of a single control button. In fact, the changeover of the automated set-up is effected more quickly than are changes on assembly lines to which the cabinets are delivered. It required considerable ingenuity to design an automated set-up so easily converted from type to type, but the result makes it possible to amortize the cost of the complete line over a far larger total production, thereby lowering considerably the tooling charge per cabinet.

Blanks of cold-rolled steel used for each cabinet measure 36 by 101⅛ in. and are 0.048 in. thick. They are cut to size from coil stock, and are delivered to the start of the automated line in stacks that are spotted on a roller conveyor for easy shifting to the first press feeder. This press is a hydraulic type that trims and notches both

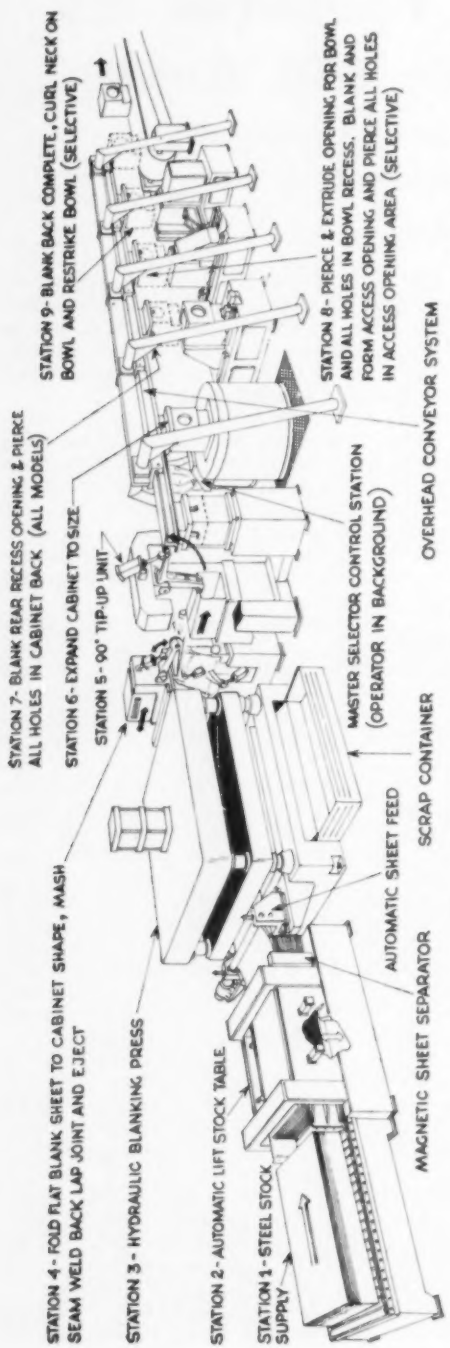


Fig. 2.—General layout drawing of washer cabinet line (Courtesy of Wallace Expanding Machines Inc.)

long edges and also pierces some small holes. Scrap cut away drops into boxes at each side of the press.

A vacuum-cup device lifts sheets from the stack. At the end of this station is a magnetic unit that causes sheets to fan out so that only one at a time can enter the roll-feed unit next to the stack. Advance into the press is by rollers that cease to turn the instant a blank strikes stops that fix its longitudinal position. As soon as this occurs, the press trips automatically and makes its working and return strokes. As the trimmed blank is released, it is fed longitudinally by rolls and is advanced to forming position in a tangent bender. At this point, the bender closes, making short-radius bends at the four corners and producing a short overlap for seam welding.

As soon as forming is completed, a mash seam welder, which is part of the bender assembly, advances the welding rolls to produce the seam weld near the centre of the back face, reducing the seam almost to single-stock thickness. The bender components open, releasing the rectangular cabinet which then is tilted up and slides down a ramp into the pick-up for the expander. Pick-up is done by a carrier on an overhead track.

Expanders Used Effectively

As in other similar set-ups, the expander is designed to stretch the walls of the cabinet and, in this case, to produce the specified oblong section as well as to hold it within close dimensions. Stretching is accomplished by four die sections that are forced outward, each moving at right-angles to the face it forms. At the proper point, four external dies are moved inward. They mate with the inner dies and, together with them, do whatever forming is required on the four faces. The dies also form top flanges inwardly. Notches made in the first press are large enough so that spaces are left between the ends of the flanges.

After the four-sided cabinet comes from the tangent bender, the cabinet is advanced on to an elevator that is part of the expander. This elevator then lowers and positions the cabinet for the expanding operation. When the expanding and face forming are completed, and all die components retract, the elevator moves the cabinet upward automatically until it clears the expander and is gripped by a carrier on an overhead track. The formed cabinet is then shifted transversely and is lowered and released at the next station. Then the carrier shuttles back, ready to pick up the next cabinet lifted from the expander.

In the expander, the dies perform certain operations on two or more faces that are needed on the particular model of cabinet being produced. Some dies have portions that are moved from one type of cabinet but remain idle for the other type.

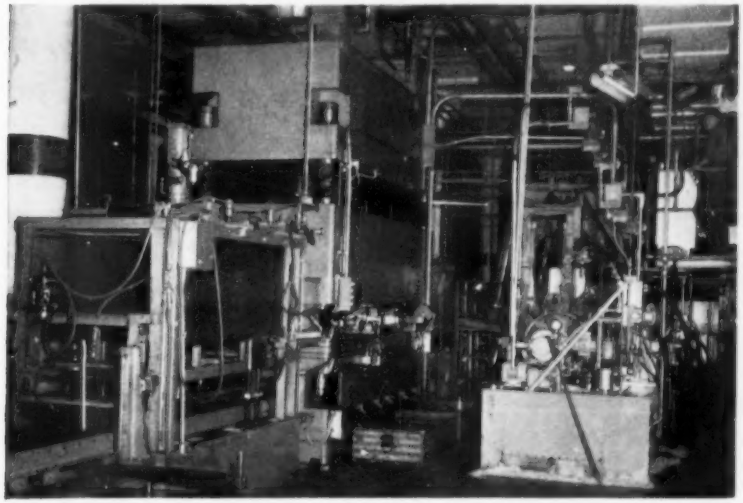


Fig. 3 (left).—Sheets are lifted one at a time by the vacuum pick-up (left) and then are advanced longitudinally by the roller feed into the press shown in centre of photograph

In the type that is to have a circular opening for a front loading door, one outer die has a punch that pierces the door hole and embosses around the opening, and the mating die has an impression into which the metal is recessed. In the cabinet needing no circular front opening or throat, the throat punch is not advanced and the face remains flat.

Dies are so made and so controlled by the sequence timer that they perform only those operations for which corresponding controls are set, and components function only when needed. Some forming is done on the back face as needed, and dies also produce side steps, when set to do so. By reason of flexible design, one machine does quite different jobs with only resetting of controls before shifting from one cabinet style to the other.

Then comes the first of three special presses equipped with dies that move horizontally. Overhead carriers shuttle back and forth to elevate, transfer, and lower each cabinet into this and each subsequent station. At the first of these stations, dies blank a rear recess opening and pierce all holes in the

Fig. 4 (below).—Tangent bender forms blank received from the press. When the two ends are overlapped, welder wheels advance for a mash seam through centre of back panel

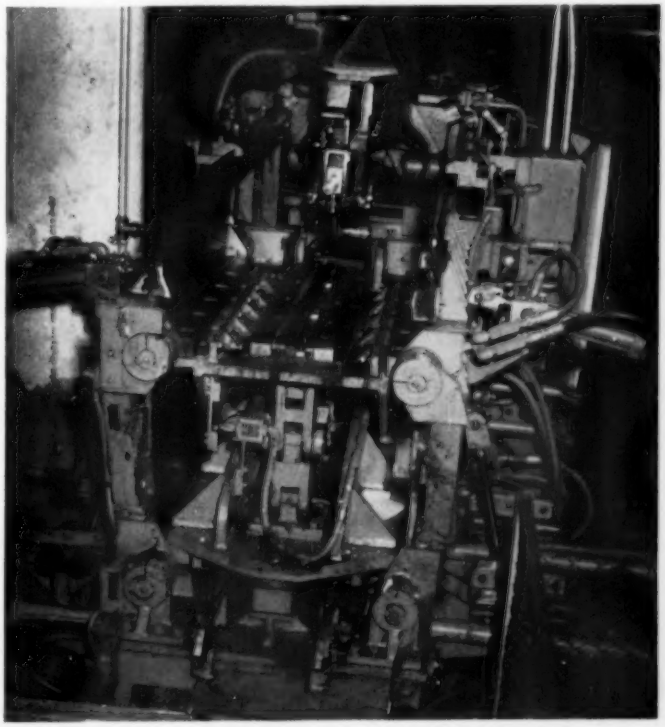




Fig. 5a.—Top view of the expander with dies open to receive the formed cabinet that is lowered by a carrier which is transported on an overhead track

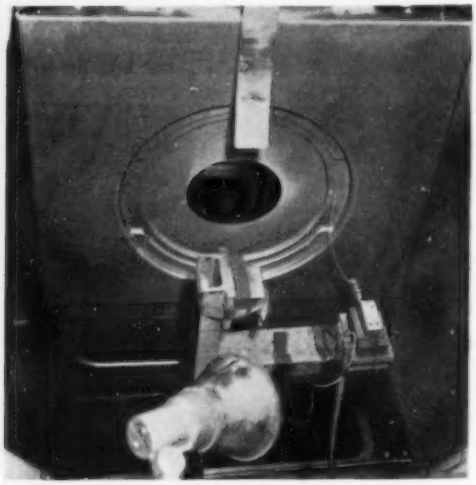


Fig. 5b.—Cabinet as it appears after elevating from the expander which has flanged the top and done some forming on vertical walls. This is station eight

cabinet back. These include holes for fasteners that support the detachable back panels and other back components. These operations are performed on both models. Movable die components in this and subsequent stations are operated by hydraulically-operated cams.

Dies in the next station operate selectively and are used only on the cabinet for the combination unit. They pierce and extrude the door opening and all holes in the bowl (or door) recess area. In the same die, the lower access opening is blanked

Fig. 5c.—Cabinet being elevated after dies in station eight where extrusion has been performed on the "bowl" and the lower opening, and several small holes have been pierced in die shown

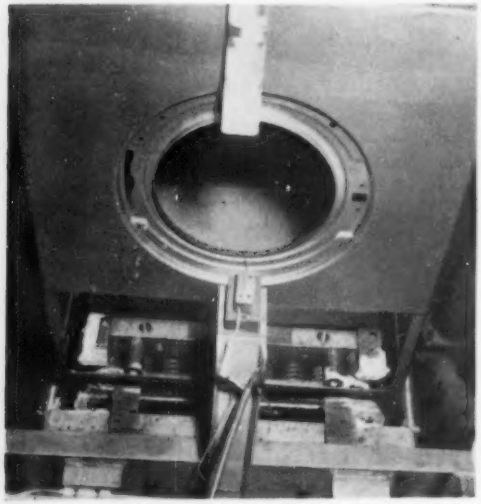
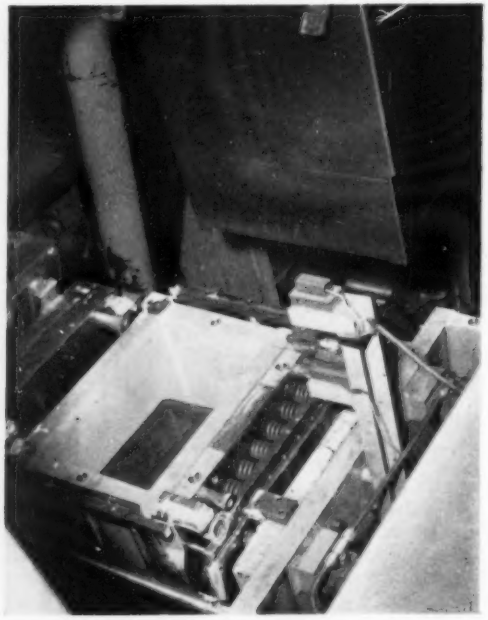


Fig. 5d.—Dies in the press at station eight into which the cabinet, shown above and at left, is about to be loaded



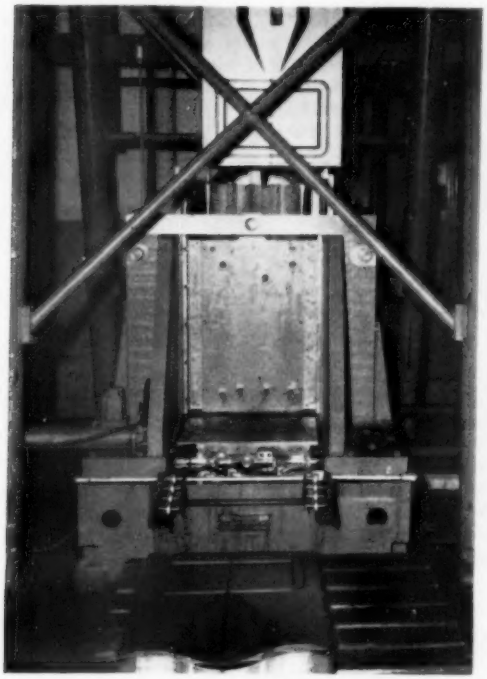


Fig. 5e.—Final station, number nine, in the automated line, with cabinet above about to be lowered. The die shown blanks out the back which drops on to the stack visible on the pallet in the foreground

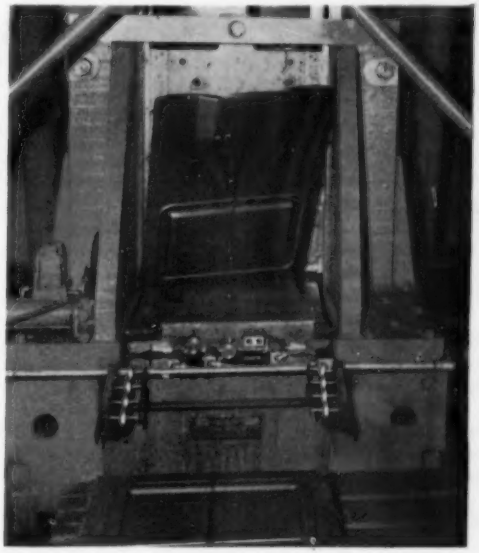


Fig. 5f.—Blanked-out back about to drop on to rolls along which the back is advanced by gravity on to the stack on the pallet

out, and the small holes at the ends of this opening are pierced. These operations are not performed on the cabinet for the vertical (Automagic) washer.

At the final station in the automated line, dies are designed to blank out substantially the whole back, which has been formed in prior operations, so that it can be employed for other purposes. Another die in the same press curls the neck at the bowl (door opening) and restrikes the bowl to set it to final shape.

Normally, only one man is required to attend the entire line, and he can observe the performance of each unit in the entire automated line. A button control panel is provided near one end of the runway and it can be used, if trouble arises, to stop the whole line, and also to permit manual button control of any unit in the line.

Each unit in the line is equipped with interlocks so arranged that no station will be fed with a sheet or partly formed cabinet until the next station is empty and ready to receive another part. These interlocks are for safety and are designed to prevent jamming during transfer operations.

Overall space required for the automated line is comparatively small, the total length being approximately 74 ft. It is possible to produce 125 cabinets an hour, which is a remarkably large output considering that, normally, only one man is needed on the line. Stacks of blanks are fed to the beginning of the line by a fork truck, and completed cabinets feed on to a conveyor at the end of the line for transfer to the finishing department.

Acknowledgement

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International Machine Tool Exhibition

PAUL GRANBY AND CO. LTD. have informed us that an error appeared in the description of their exhibits which they provided for the preview of the above exhibition published in our June, 1960, issue. The Wilhelmsburger plate-bending and levelling machine on show is the 5-roll FWV type not the 7-roll SWV type as stated.

Also the caption to Fig. 23, one of the exhibits of Holden and Hunt Ltd., should read 15-kVA spot-welding machine.

NEW PLANT FOR THE PRODUCTION OF SILICON STEELS

Increased Demand Necessitates Expenditure of £4-million

ACCORDING to a report in " The Dragon," the monthly publication of the Steel Co. of Wales Ltd., additional plant, which will cost £4,000,000, is to be installed at Orb Works. It will enable the Newport Division of the Steel Company of Wales to meet the increasing demands of the electrical industry for high-grade cold reduced silicon steels.

The company has embarked on a further development scheme designed to increase output of electrical sheet steel by some 45,000 tons per annum.

It is expected that the new plant will come into operation late in 1961 and early in 1962. It is not anticipated that there will be any material change in total manpower.

This new scheme, the third to be carried out at Orb Works since 1955, provides for the installation of a second 48-in. cold reduction reversing mill adjacent to the existing mill.

In addition, the present 48-in. mill will be modified to permit the rolling of double-weight coils.

Other items of the project include additional heat treatment plant and increased insulating facilities, together with modifications to the existing processing equipment.

Sendzimir Mill

To increase production of very thin oriented steel strip in thicknesses of the order of 0.001 to 0.004 in. a new 14-in. Sendzimir mill will be installed. The product of this unit will go towards meeting the need for material for specialized applications including electronic devices associated with aircraft, missiles, nuclear development, etc.

Orb Works have, for over half a century, been leading makers of the electrical steels required in increasing tonnages by the builders of dynamos, motors, transformers, generators and smaller equipment such as radio and television sets.

Well over 50 per cent of the sheet and strip material produced in this country for such purposes comes from these works.

Modernization has been proceeding steadily since the last war, with the result that the plant is right in line with that of American makers.

In 1955 the company launched a £2 million project for the Newport Division for the production of cold reduced silicon steel in coil form.

Hardly had this plant come into operation when, in 1958, a second £2 million scheme was announced to increase production. Plant installed under this second stage is now coming into operation.

The announcement of the latest stage of this continuous programme of modernization and development is evidence of the company's determination to keep Orb Works at the very forefront of the manufacture of electrical steel.

Its completion will play a big part in supplying electrical manufacturers with additional tonnages of the high grade material which they have become accustomed to expect from Newport.

B.I.S.R.A. Report

(*Continued from page* 522)

Company of Wales (Steel Division). Some preliminary results have been obtained and these indicate that the method of experiment is satisfactory. When reliable determinations have been made of these coefficients, under different mill operating conditions, it is intended to study the behaviour of different control systems applied to the mill by experiments on an electronic analogue simulator.

Use of the Swift Cupping Test

(*Continued from page* 528)

punch, it is an unsuitable test for material which is intended for deep drawing, as opposed to pressing. It seems clear that the flat punch is the most suitably contoured punch for this type of metal forming, and certain practical results confirm this.

At present, therefore, it appears that the Swift test may not give any more information than the Olsen test. It seems probable that a modified Olsen test, using a bigger ball would help to reduce the sensitivity of this test to gauge variations and might produce a test which would be useful for sheet metal in industries producing light-gauge pressings of the motor-car-body type, where the shape is largely obtained by stretching over the head of the punch.

References

1. B.I.S.R.A. Report MW/E/85/54.
2. Pearce, R., *Sheet Metal Industries*, 1953, December, **30**, p. 1077.
3. Swift, H. W., " Plastic Bending Under Tension," *Engineering*, 1948, **166**, p. 357.

FACTORY EQUIPMENT ON SHOW

This year's Factory Equipment Exhibition will be held at Belle Vue, Manchester, from September 21 to October 1. The exhibition will be open both to the trade and to the public.

7

SHEET METAL DATA SHEET

Punching in Sheet Metal

Compiled by J. W. Langton, M.B.E., B.Sc.(Lond.), M.I.Mech.E.

NOMENCLATURE

PUNCHING is a shearing operation where the portion cut out or sheared is not required, to distinguish it from blanking where the sheared-out portion is the part required.

Punching and piercing are used usually as synonymous terms.

Perforating is a term usually applied to the multi-piercing of smaller diameter holes.

PRESSURE AND WORK DONE

The general remarks on shearing in data sheet No. 1 apply here.

Thus—Pressure required for Punching $= \pi DT \times fs$. Where D = hole diameter, T = stock thickness, fs = shear stress. (Recent experiments query the use of shear instead of tensile stress.)

A simplified version of the above general rule for mild steel about 24 tons per sq. in. is:—

Pressure (tons) = 70 DT.

Work done in Punching is thus Punching Pressure x Stock Thickness. The pressure for stripping may have to be taken into account here. It can vary considerably to be something between $2\frac{1}{2}$ and 20 per cent of the punch pressure ; an average figure might be of the order of 2 tons per in. length cut by stock thickness. In multiple punching the punch lengths may be "staggered" to reduce the punching pressure at any one instant, but the total work to be done is unaffected.

CLEARANCES AND SHEAR

There must be clearance between punch and die in accordance with metal thickness (*cf.* again Data Sheet No. 1). Note the punch controls the hole size, so the die opening is increased accordingly. The greater the clearance consistent with reasonable quality of hole punched, the less effort required.

Some reduction in effort can be secured by shearing the faces of punch and die. It is usual to shear one of the faces of one of them, but not both. Various shapes of sheared faces are possible—none of them have special virtues, the main idea being simply to cut part of the periphery of the punched hole at any one instant. The hole in the die must have angular shear, even if minute ($\frac{1}{4}$ deg.) Some prefer to have the hole straight for a short distance before the angular shear begins, to maintain hole diameter longer after grinding. Providing the die clears the punchings satisfactorily, in general the smaller the angular shear the better.

In the general design of punch and die and punching machine, rigidity is everything. A stout punch with generous corner radius to increase holding diameter will last much, much longer.

Note.—Minimum diameter of hole punched is approximately that of stock thickness.

TYPES OF MACHINES

In all types of punching machines, the main specification centres around maximum size of hole punched and the maximum thickness such hole can be punched through, and the gap or distance from centre of punch to back of throat of machine. It is as well to be careful in reading the details of the punching—the specification may give, say, $\frac{1}{2}$ in. diameter through a $\frac{1}{4}$ in., but there may be possibilities of punching a larger size hole through thinner material—this information is not always given. Obviously any punching machine has the actual capacity to punch larger holes through thinner material—the restrictions lie in the linear dimensions of the punch and die mounting and the ability to get rid of the punchings. Considering work capacity alone, then very obviously

$$DT = dt.$$

So a punch with capacity of 1 in. diameter through $\frac{1}{2}$ in. would be capable of punching 2 in. diameter through a $\frac{1}{4}$ in., etc.

Hand-operated Punching Machines

The maximum capacity limit here is of the order of punching 1-in. diameter holes through $\frac{1}{2}$-in. mild steel, and at the top limit, ratchet action gearing is required.

The very light machines (of the capacity order of $\frac{1}{32}$ to $\frac{1}{16}$ in.) can be obtained for portable use. The medium range is usually bench mounting and hand-operated (but the heavy machines can be mounted on a truck, and so given portability). Maximum gaps are of the order of 18 in. but 6 to 10 in. are more common.

For punching rolled sections as angles, care has to be taken to see that the section can be inserted and positioned correctly between the punch and die. In general the usual hand punches for sheet metal will not serve for punching sections without attention to die and bolster and/or punch and punch mounting, and possibly stripper.

Special versions of hand punches specially suitable for sections can be obtained, as can punches for punching very near to corners.

This data sheet has been written on machines specifically designed for punching work. It is obvious that any form of press, for example, can be adapted to serve as a punching machine if equipped with punch and die. Punch and die sets can be obtained for use in light presses to assist this adaptation. For pressing smaller sizes of holes in light sheet metal, foot presses for example (permitting both

7 SHEET METAL DATA SHEET

Punching in Sheet Metal (Cont.)

hands to be free for feeding and removal of work) should always be considered.

The need for positive stripping of the work should always be kept in mind.

Hand Turret Punches

Hand turret punches are used where it is necessary to punch a smaller number of a range of varying sized holes. A turret which can be revolved comes, usually, in about 12 different sizes of punches and dies and any one can be brought into service quickly, by bringing it into the operational station to connect to the hand lever. Common capacities are up to about $\frac{3}{4}$ in. through $\frac{5}{16}$ in. as a maximum. The gaps are fairly small, usually of the order of about $3\frac{1}{2}$ in.

Multi-purpose Punching Machines

Hand-punching machines can be obtained with a quick-change tool head, so that by changing this head, operations other than punching, such as cropping, notching, etc., can be carried out.

The maximum tonnage in such hand machines is of the order of 30 tons, or punching capacity $\frac{3}{4}$ in. through $\frac{1}{2}$ in., or square notching in angle iron 2 in. x $1\frac{3}{4}$ in. x $\frac{1}{4}$ in.

Power-punching Machines

Single purpose power-punching machines have usually one main virtue over adaptations of power presses for the purpose, in that they are usually designed to have deep gaps; up to 50 in. can be obtained. Even so, they are also usually designed to have other uses as notching, etc., as secondary use possibilities. Tonnages can go up to 200 or even more, and the design principles follow, in most cases, those of mechanical power presses. Strokes per minute vary from about 30 at the large tonnages to 50 in the smaller ones, but very light punching using ungeared units can, of course, be carried out in lighter machines at direct driven power press rates—*i.e.*, of the order of 100 per min.

Power punching is incorporated in machines for carrying out a series of operations, as shearing, notching and section cropping. Here the punching capacity is generally made to line up with the rest of the work usually required on the sections. An example—if the machine deals with 6 in. x 6 in. x $\frac{1}{2}$ in. angles, the maximum punching is of the order of 1 in. diameter through 1 in.

Multiple Punching

Multiple punching is the punching of a number of holes per blow of the machine used, and the machine used is fairly obviously some form of wide ram press.

Presses can be obtained specifically designed for this purpose, called multiple punching presses, and these are usually double sided presses with fairly large distances between the sides, and narrow front to back.

In very many cases, however, the press brake is used for this purpose, and it is certainly a good answer. Calculation of capacity required is easy enough, but if staggered punching is resorted to in order to keep the punching load down, the point about total work previously mentioned should be kept in mind to ensure there is sufficient work energy. Apart from the real necessity arising in order to "stagger," it is useful to arrange the punching in this manner anyway. The staggering should be "balanced" across the tool, *i.e.*, starting from centre and working out both ways, or from the two sides and working into the centre.

Multiple-punch Tooling

There are usually two general choices of multiple punch tooling (*a*) a virtual one press tool in which punches and dies are set in top and bottom bolsters at fixed pitches or (*b*) by the use of punching units which are essentially self-contained punching tools whose pitch may be varied as required. The particular circumstances determine the choice, but the main factors are cost and desirability of pitch variation. The one press tool is usually the cheaper, and if pitch variation is always present then the units are usually the best answer. Set-up time with the one press tool can be negligible—gauges can make the unit change-over simpler.

In all such tooling, positive stripping is to be preferred.

Power Turret Punches

Turret punches, as described in hand punches, can be obtained power driven in a much wider range. Here the machines are not only power driven for the actual punching action, but can be obtained with the turret itself power driven, with selection by hand lever. In addition special work tables can be supplied with the machine to permit much easier and more accurate location of the work to the punches. These more elaborate machines are often used for the multifarious punching work in radio chassis, switchboards, electrical boxes, etc. The tonnages can go up to 100 or more, punching holes up to 6 in. in $\frac{3}{4}$ in. thick with gaps about 25 in., and special work tables to take sheets 8 ft. by 4 ft.

GENERAL NOTES

Heat Treatment

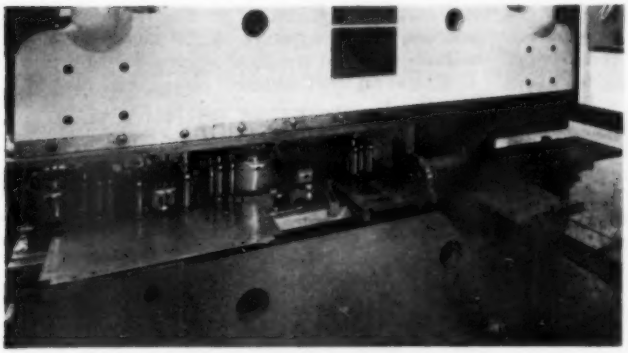
It is most advisable to heat treat fully both punch and die for sheet-metal punching. The die should be harder of the two, as being usually more costly to replace. The punch should be well tempered from the shank upwards so that only the working portion is reasonably hard.

Non-circular Punching

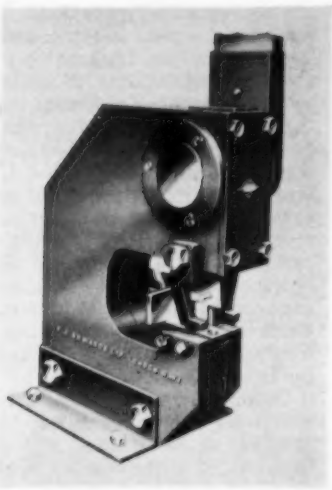
All the above remarks apply, of course, just the same in non-circular punching, and there is one main additional point. Means must be provided to prevent the punch from turning in relation to the die, and therefore, the usual elementary means of gripping the punch shank with one screw may not serve. If the stripper fitted is a solid type then it serves in the main for location of the two, but unless the upper portion of the shank is made to fit the stripper neatly, better means of guaranteeing the location must be provided. Any misalignment of punch and die will tend to result in a high mortality in punches, and if this obtains, then this possible cause should be first investigated.

SHEET METAL DATA SHEET 7

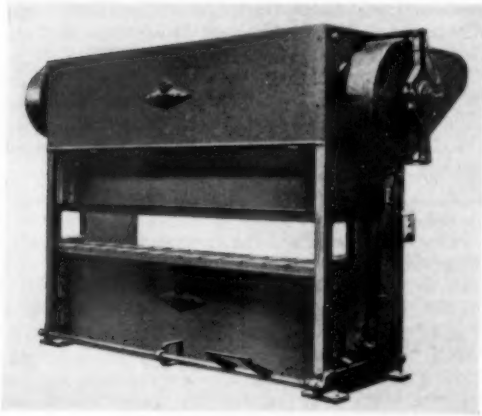
Punching in Sheet Metal (Cont.)



(Above).—Redman multiple punching and cropping units



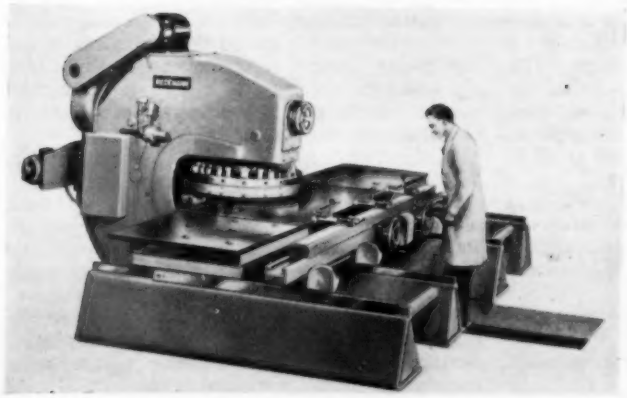
(Above).—Edwards hand-operated punch

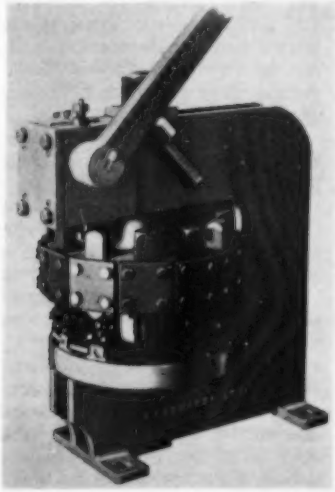


(Left).—Special multiple-punch press (Edwards)

(Below).—Turret-punching machine (Edwards)

(Below left).—Turret-punch press (British Wiedemann)





INSTITUTE OF SHEET METAL ENGINEERING

Notes on Forthcoming Activities

COLD EXTRUSION OF STEEL

TECHNICAL aspects of the production of steel components by a cold extrusion process which were first discussed in this country at a Conference organized by the Institute in 1953, have evoked an increasing amount of interest during recent years. A further Conference on this subject has, therefore, been arranged at which papers will be presented by a number of authorities with practical experience in this field. This Conference will be held in the City Hall, Sheffield on November 21-23 next. The programme will include over 12 papers covering various aspects of the subject, and it is expected that a number of films showing the operation of the process will be shown. Typical components manufactured by cold extrusion will be on display and arrangements have been made for a visit to one or more works where the process can be seen in operation.

Detailed programmes and application forms for tickets for this meeting will be sent out to all members of the Institute and others who record their interest in the next few weeks.

TRIPLE CONFERENCE IN 1961

In May, 1961, a three-cornered meeting will be held in London between the Institute, the American Pressed Metal Institute and the German Forschung Fur Blechverarbeitung. It is anticipated that the delegation from the U.S.A. will number about 60 representatives of metal pressing firms, who, in addition to participating in the meeting, will be visiting works of technical interest to them in the U.K. and on the Continent.

WORKS TOUR IN SOUTH WALES

The tour of the works which has been a biennial feature of the Institute's programme since 1948, will this year be staged in South Wales. The tour will start in the Cardiff area on October 3, proceeding to the Swansea area for the next two days and concluding with visits to works in the Merthyr Tydfil area for the last two days of the week.

Companies who have extended invitations to the Institute to include their works in the tour are as follows: Guest Keen and Nettlefolds (South Wales) Ltd., Cardiff; Simmonds Aerocessories Ltd., Treforest; British Iron and Steel Research Association Laboratories, Sketty Hall; Aluminium Wire and Cable Co. Ltd., Port Tennant; Morris Motors Ltd., Llanelly; The Steel Company of Wales Ltd., Tinplate Division, Velindre; The Anglo-Celtic Watch Co. Ltd., Ystradgynlais; Hoover (Washing Machines) Ltd., Merthyr Tydfil; Lines Bros. Ltd., Merthyr Tydfil; Pilkington Brothers Ltd., Pontypool.

BETTER GAUGE IN METAL STRIP PRODUCTION

Further Step in Automatic Control

A NEW device for automatically controlling the gauge of cold metal strip has been developed by the English Electric Co. Ltd., and experience at the first installation shows that it makes several times the amount of gauge adjustment the operator normally makes by hand.

The system consists of a flying micrometer, a control panel and the main control cubicle. The flying micrometer, mounted at the edge of the strip, measures the gauge of the rolled material. On a reversing mill a micrometer is mounted on each side of the rolls, and the intended gauge is registered on the front of the micrometer.

The operator sets up his tolerances on the control panel, which is conveniently mounted near the mill. Generally this is done by a multiposition switch, tolerances of $\frac{1}{4}$, $\frac{1}{2}$, 1 and $1\frac{1}{2}$ thousandths of an inch being typical figures.

On automatic control a continuous signal is transmitted to the control cubicle. When the error is greater than two thirds of the tolerance setting, the screw-downs are operated.

For a reversing mill the control cubicle contains three computing amplifiers, one for each of the two flying micrometers and one as a spare.

When the mill is rolling slowly, that is up to a critical speed, a sampling control system is used. After an error has been corrected an electronic time delay ensures that the screw-downs do not operate again until the corrected gauge has passed through the flying micrometer. This prevents the system " hunting " for the correct gauge.

When the speed is greater than the critical speed the system changes to continuous control under the automatic operation of a relay in the control cubicle. Hence the fastest correction possible is obtained with maximum stability.

The incorrect setting of the flying micrometer, the failure to apply the micrometer to the strip, a break in the strip or the running of the " thick end " through the flying micrometer would all show an artificial gauge error, causing incorrect and possibly dangerous operation if the automatic gauge control were allowed to respond.

An excess error relay immediately prevents this and manual control is made available to the operator. Manual control is always available whether automatic gauge control is selected or not.

SHEET METAL NEWS

FEATURING EVENTS AND PERSONALITIES IN THE INDUSTRY

FIRTH CLEVELAND ACQUIRE J. J. HABERSHON AND SONS

Combination of Interests for Future Expansion and Mutual Benefit

THE acquisition by Firth Cleveland Ltd., London, S.W.1, of J. J. Habershon and Sons Ltd., of Holmes Mills, Rotherham from the Iron and Steel Holding and Realisation Agency, for £700,000 for the share capital and £400,000 for the outstanding loan due by Habershon to I.S.H.R.A., has been announced as a step designed for the mutual benefit of both concerns to provide a sound, well-knit basis for future expansion as well as furnishing a measure of stability against possible depression ; this is in accordance with the general policy pursued by the Firth Cleveland Group, who already have the following steel interests; Firth Cleveland Steel Strip Ltd. and its subsidiary, the Tenuous Steel Co. Ltd., The Firth Co. Ltd., Richard Hill Rolling Mills Ltd. and the Sheffield Wire Rope Co. Ltd.

Habershons originated in 1757 when Walker Brothers bought a wrought iron slitting mill from the Earl of Effingham ; the first hot-rolling mill was laid down in 1794 and for many years Walker's had a high reputation for crucible steel manufacture and iron castings. Holmes Tin-Plate Works, as they were known, were bought by Matthew Habershon in 1829 and were soon converted into steel rolling mills, much of the product being rod. The development of steel strip production was co-incident with the introduction of the steel nib, crinolines and the bicycle industry 70 years ago and a logical sequence from the bicycle to the motor cycle and the automobile industry.

The firm, J. J. Habershon and Sons Ltd., was incorporated as a private company in 1920, and became interested in the production of stainless-steel strip from the earliest days of its invention ; it was A.I.D. approved for the supply of raw materials to the aircraft industry in 1926, being then the largest manufacturer in the United Kingdom, and during the 1939/45 war, Habershon steels were in almost every aircraft flown. Gradually over the years, Holmes Mills have extended, as production and modernization increased, to its present 36 acres and include new high-speed mills, some specially designed, which have been recently automated and electronically controlled. The most important of the new plant is the remarkable Sendzimir planetary hot-rolling mill (*see* page 511), the second of the first four of such installations in the world; this installation enables hot steel slabs to be reduced by more than 90 per cent in thickness at one single pass into long continuous strip, the whole process, including furnace control, being operated from electronic control desks. Teething troubles associated with the planetary hot mill have been reflected in the financial results for 1957/9 but these have now been overcome and it is expected that when it is working at full capacity its output will increase by 50 per cent.

Increased Turnover

This new acquisition is expected to bring the turnover of the Firth Cleveland steel interests to about £11,000,000 currently. The board of J. J. Habershon and Sons Ltd. has been reorganized and will now be : Mr. Charles W. Hayward, chairman ; Mr. John W. Tonking (managing director of Firth Cleveland Steel Strip Ltd.), deputy-chairman ; Mr. John W. Habershon and Mr. R. P. R. Habershon, joint managing directors ; Mr. E. W. Day (sales director of Firth Cleveland Steel Strip Ltd.) and Mr. A. E. Gilbert, Mr. T. D. Dunlop and Mr. S. R. Hague of the Habershon Board. Mr. A. E. Gilbert has been invited to join the board of Firth Cleveland Steel Strip Ltd. The decision to unite the forces of Firth Cleveland Steel Strip Ltd. and Habershons arose from a recent market survey which indicated that Firth Cleveland could sell twice as much spring steel strip as they now produce and that the expanding motor-car industry will create even further demands. From small beginnings in 1950, when their Tipton Works consisted of an old packing workshop and three small offices, Firth Cleveland Steel Strip Ltd. has grown so that it now makes about half of the tonnage of spring steel strip produced in England today, disregarding razor and tape-measure steel with which they are not concerned, and 70 per cent of the motor cars made in England have Firth Cleveland steel strip clutch plates. The company have for some time bought some of their raw materials from Habershons and an examination of the activities of the latter company showed that they were complementary to those of Firth Cleveland and that by a full exploitation of the resources of the two companies the demands of existing customers and future market probabilities could be met without a major expansion programme at Firth Cleveland Steel Strip Ltd. with all that would be involved in terms of disruption of present production, alterations to buildings, long delay and heavy capital expenditure.

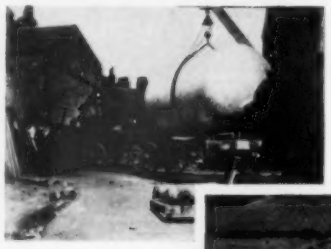
GOLDEN JUBILEE OF A.P.V.

ON June 10 The A.P.V. Co. Ltd. celebrated the fiftieth anniversary of its foundation. The company was started in Wandsworth, London, in 1910 by Dr. Richard Seligman, as The Aluminium Plant and Vessel Co. Ltd., to develop commercially a patent for the welding of aluminium. It was the first company to produce large vessels in aluminium as the industrial application of this metal had previously been handicapped by the difficulty in welding.

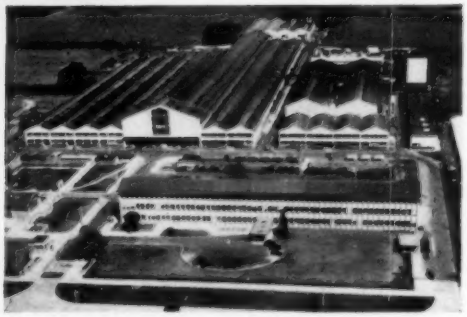
The subsequent development of welded fabrication in aluminium, and later in stainless steel, the invention of the "Paraflow Plate Heat Exchanger" in 1923, and the growth of the company as process engineers, built The A.P.V. Co. up as one of the leading manufacturers of process plant for the dairy, brewery, food, chemical and related industries.

Today The A.P.V. Co. employs nearly 2,000 people in its very modern factory at Crawley, Sussex, and it has created a large overseas organization based on eight associated companies, four of them with their own factories.

During the whole of this 50 years of steady, healthy growth The A.P.V. Co. has retained its independence, and its founder, Dr. Richard Seligman, although now retired from the chairmanship, is still with the company today as president.



Left.—The original A.P.V. works at Wandsworth, 1910



Right. — The present A.P.V. works at Crawley Sussex

Change of Name

IT has been announced by Head Wrightson Colliery Engineering Ltd. of Sheffield, a subsidiary of Head Wrightson and Co. Ltd., of Thornaby-on-Tees, that the company's name has been changed to Head Wrightson Minerals Engineering Ltd.

The company has been known for many years as one of the leading specialists in the design and supply of colliery surface equipment, but in recent years it has been expanding its activities in other fields, in particular in the treatment of minerals other than coal.

Another important expansion will take place shortly in connection with iron ore treatment and it was felt that it would be an advantage if the company's name gave an indication of its widening scope.

Its interest in, and capacity for, work for the colliery industry at home and abroad will be maintained, and there will be no change in the organization or direction of the company.

First Honorary Diploma in Technology Award to Lord Hives

AT a recent meeting the National Council for Technological Awards conferred on Lord Hives, the Council's first chairman and a former chairman of Rolls Royce Ltd. an Honorary Diploma in Technology (Engineering).

Lord Hives was appointed chairman of the National Council in July, 1955, by the Minister of Education, Sir David Eccles, when the Council was first established. He resigned from the chairmanship in January of this year. During Lord Hives' chairmanship the Diploma in Technology became firmly established and, at the time of his resignation, 3,746 students were following 87 courses leading to the Diploma in Technology at 22 colleges. Towards the end of his period of office the Council established their higher award, Membership of The College of Technologists, which it is intended shall have the academic standard of the Ph.D. degree of a university and be granted for a programme of work carried out jointly in industry and in a college.

Griffin and George Secure German Agency

GRIFFIN AND GEORGE Ltd., have secured, against competition with other well-known British firms, representation for the Deutsche Innen und Aussenhandel Elektrotechnik, and DIA Feinmechanik-optik and the DIA Kulturwaren as selling agents for Great Britain, Australia, South Africa, and Eire

SIMA CONTINUES TO GROW

THE continued expansion of the Scientific Instrument Manufacturers' Association of Great Britain (SIMA), Sima House, 20, Queen Anne Street, W.1, is evident with the following new members recently elected by SIMA Council:—

Wilkinson Sword Co. Ltd., Sword Works, Southfield Road, London, W.4; Claude Lyons Ltd., 76, Oldhall Street, Liverpool, 3; Bruce Peebles and Co. Ltd., Tay Works, Bonnington, Edinburgh, 6; Nazard Ltd., Belmont, Surrey.

Amplivox Ltd., Wembley, Middlesex, and B. and R. Relays, Temple Field, Harlow, Essex, have been elected as associate members. This brings the total now to 149 full members and 30 Associate members, making a total of 179 firms in SIMA.

METAL INDUSTRIES EXPANSION

METAL INDUSTRIES LTD. have acquired the firm of John Lee, of 80, Corporation Street, Belfast, 1, and Milewater Basin, Belfast Harbour, scrap iron, steel and metal merchants.

The price paid was £45,750 of which £9,100 is to be satisfied by the allotment to the vendors free of cost of 2,600 fully-paid ordinary shares of £1 each in Metal Industries Ltd. and the balance in cash.

The business is being transferred immediately to Cox and Danks Ltd., a wholly-owned subsidiary of Metal Industries Ltd., but will be conducted until further notice under the name of John Lee.

Society of Chemical Industry Appoint New President

SIR ALEXANDER FLECK, K.B.E., D.Sc., F.R.S., has been appointed president of the Society of Chemical Industry for 1960-61 in succession to Mons. E. J. Solvay.

Sir Alexander will be installed as President at the Annual Meeting of the Society at Bristol in July.

Sir Alexander has received the Messel and Castner Medals of the Society of which he has been a member since 1917. He retired from the Chairmanship of Imperial Chemical Industries on 29th February, 1960.

AMERICAN STRIP MILL DRIVES REQUIRE 54,000 H.P.

THE largest main drive motors ever used on a hot-strip finishing train will make Great Lakes Steel Corporation's new Detroit mill the most powerful of its kind in the world.

The five 8,000-h.p. and two 7,000-h.p. double-armature motors are part of a £2.8 million electrical system being supplied by U.S. General Electric for the seven-stand, 80-in. mill, which can be operated, on certain schedules, at about 2,700 ft. per min., 500 ft. per min. faster than the usual maximum speed of hot strip finishing mills.

Previously, the largest General Electric motors ever used to drive a finishing train were rated at 5,500 h.p., and total horsepower did not exceed 38,500, as compared with the 54,000 h.p. the new motors will provide.

According to G.E. engineers, the motors are the result of a complete re-design programme and will include such new features as constant-pressure brushholders, high-temperature compound field coils, easily removable covers and an improved tachometer drive. Individual 5,600-kW. and 6,400-kW. rectifiers will transmit power to each of the 7,000-h.p. and 8,000-h.p. motors, respectively.

Speed regulators, acting through rectifier voltage, are expected to make possible more uniform operation, full mill utilization and increased production, while an automatic gauge control, part of the overall system, will enable the mill to deliver more strip that meets with measurement specifications.

The new mill is scheduled to start operations this autumn.

INCREASING SOUTH AFRICAN DEMAND FOR STEEL

FROM South Africa, Barclays Bank D.C.O. reports that the tempo of the Union's demand for s eel during the last few months has gained momentum. Most rolled steel products are in short supply and ISCOR has been obliged to introduce a system of allocations notwithstanding the fact that all ISCOR mills are producing at maximum capacity.

Re-stocking has proved to be a decisive factor in the upward swing in domestic demand. The steady depletion of stocks during the period of recession left consumers with less than normal reserves. This stock replenishment has been superimposed on an increased level in the demand for immediate fabrication, resulting in an overall demand in excess of available capacity.

ISCOR has continued with its policy of reference to the local market in times of short supply, and with the exception of limited tonnages to neighbouring territories no export orders for rolled steel products have been accepted. Shipments of pig iron surplus to domestic requirements and in fulfilment of previously accepted orders continue.

PRESSED STEEL CO. ANNOUNCE LARGE-SCALE EXPANSION PLANS

THE Pressed Steel Company Ltd. announce that as a result of the large-scale expansion programme being undertaken by the motor-car industry and the resultant increased requirements for motor bodies, it has become necessary to extend the company's motor-body-making facilities. This will be done not only by extending existing plant at Swindon, but also by the introduction to the Linwood factory near Glasgow of large-scale body production alongside the manufacture of railway rolling stock. This will entail, in addition to the provision of necessary equipment, an enlargement of the existing Linwood factory space. Car-body production has already commenced there and will continue on an increasing scale. The directors are also planning to expand the company's capacity for the manufacture of press tools. They have acquired a site for that purpose on the Simonside Trading Estate, Leam Lane, Jarrow, and are negotiating with the Board of Trade for the construction of a factory.

AMERICAN POLISHING MACHINES TO BE MADE IN U.K.

A 44-IN. perimeter universal open-centre polishing or buffing machine produced by Acme-Efco Ltd., Sheerwater, Woking, Surrey—a new company jointly owned by the Acme Manufacturing Co. of Detroit and the Electro-Chemical Engineering Co. Ltd. Acme-Efco Ltd. will be concerned with the sales, manufacture, installation and servicing of automatic polishing and buffing machines in this country. The telephone number of the new company is Woking 5222 and the sales manager is Mr. R. G. Hughes.



Cambridge Greets the "Four Corners"

THE Cambridge Instrument Co's 36th annual sales conference brought agents' representatives from Australia, Canada and India, as well as from most western European countries. In addition, home-based representatives of firms operating in China, India, Egypt and south-east Asia, together with those selling in some eastern European countries, were present. It was the largest gathering of overseas representatives yet to attend the Cambridge Instrument Co.'s conference. This was appropriate, since emphasis this year was on the need to increase overseas sales in the face of greater competition.

The conference included visits to Cambridge Works, where the new research building was seen by most overseas representatives for the first time, to the Muswell Hill (London) Works to see the expansion now in progress there and to the mechanical thermometer division at Finchley, where Minican Recorder and Numalec Controllers are in production. The party also visited the enlarged premises at 13-14, Grosvenor Place, the company's head office.

GRANTS FOR RESEARCH

IN 1959, the Department of Scientific and Industrial Research increased the number of grants to universities and technical colleges for research in every field of science except mathematics. Details of a few of these are as follows :—

Steel Research at Sheffield

A grant worth £36,000 to Sheffield University for work on the transformation of metals, enables Professor A. G. Quarrell and his colleagues in the department of Metallurgy to purchase new apparatus, offering greatly improved techniques in the study of the structure, composition and properties, both microscopic and macroscopic, of steels. The research programme includes a study of the fracture surfaces of various cast steels, a more precise determination of the role of alloying elements, the effect of cooling rate and the influence of "trace elements." Structural changes during the working of iron-manganese-carbon alloys, creep properties, the constitution of slags and slag-metal reactions and many other research problems of significance to the steel industry are also being undertaken.

Microscopy

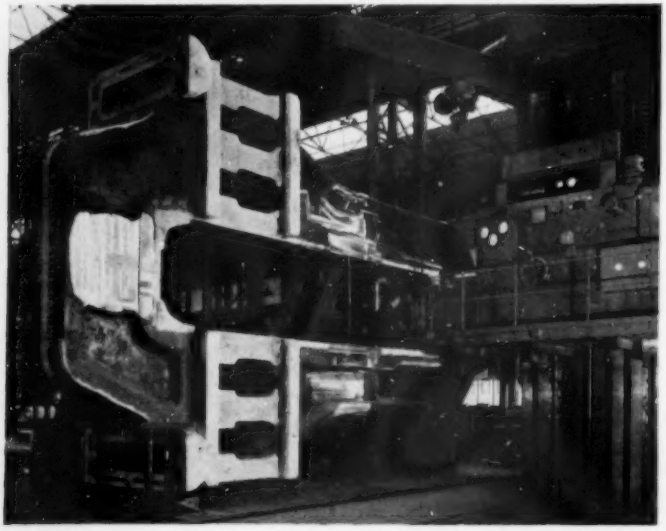
A break-through of great significance in the field of metallurgical research has recently been made by workers at the University of Cambridge, using electron-transmission microscopy, and it is now possible to follow by cine-techniques the arrangements and motion of dislocations when a metal foil is strained to breaking point. Microstructures down to the atomic scale can be seen for the first time as well as what happens when a pure metal is suddenly cooled from a high temperature, and how nuclear radiation damages the crystal structure. Workers in this field of research include Dr. P. B. Hirsch of the Cavendish Laboratory, whose work is supported by a grant of £18,730, and Professor A. H. Cottrell, of the Department of Metallurgy, Cambridge, who was granted £15,000 for electron microscopical study of metallurgical problems.

Chemistry

Two grants have been awarded, each over £20,000, for the purchase of the Metropolitan Vickers Mass Spectrometer M.S.9, which distinguishes between simple ions of the same integral mass but differing constitution; the spectrometers will be used for molecular studies by Professor Sir Christopher Ingold of University College, London, and Dr. R. I. Reed, at Glasgow University. Professor G. O. Jones of Queen Mary College, London, has also received a grant of £13,000 for spectroscopic work at extreme infra-red wavelengths.

150-TON ROLL HOUSING

A 150-TON roll housing being machined on a 10-in. ram-post milling machine in the Darnall Works, Sheffield, of Davy and United Engineering Co. Ltd. The housing was produced by English Steel Castings Corporation Ltd. and is one of two intended for the new 52-in. by 138-in. slabbing mill which Colvilles Ltd. are building to feed the 68-in. Davy-United hot strip mill being built at Colvilles Ravenscraig Works.



ALUMINIUM CO. OF CANADA TO INSTALL NEW FOIL MILL

ALUMINUM CO. OF CANADA LTD., principal operating subsidiary of Aluminium Ltd., have announced an investment of $1,600,000 at their Kingston, Ontario, plant for the purchase and installation of a 60-in. four-high foil rolling mill. This will be the second machine of this size—the largest Canadian aluminium foil rolling mill and reflects the growing market in Canada for Alcan foil. A new extension to the Kingston foil mill building is being constructed.

BICENTENARY OF THE SHEFFIELD SMELTING CO. LTD.

THE Sheffield Smelting Co. Ltd. which was founded in 1760 by John Read who set up business as a refiner, celebrates its bicentenary this year, and it is, therefore, not inappropriate to recount some of the steps by which this one-time small man business has retained its identity and grown into one of the biggest organizations of its class.

At the time the firm started, silver and copper were bonded and worked together into a variety of wares now known as Old Sheffield Plate, and craftsmen who could manipulate plated metal found that they could do the same with sterling silver; it was not until the arrival of John Read that there was anybody in Sheffield who could recover the valuable scrap which inevitably arose. By 1782, Read had started smelting, appointed agents in London and Birmingham and leased a 40-acre site near Royds Corn Mill, between Sheffield and Attercliffe; the business continued to expand, foreign agents being appointed and Read's nephew and two sons were taken into partnership at the new works at Royds Mills. With silverware and jewellery becoming fashionable during the Victorian era, many improvements made in the smelting and refining processes, included the installation of a plant for recovering the solids from furnace gases. Welfare was not ignored—a bonus scheme was started in 1865 and by 1890 when the company became incorporated, a 48-hour week was introduced; holidays with pay were granted in 1890.

Further expansion led to the acquisition of premises in Arundel Street, Sheffield, where rolling and wire drawing equipment were installed and many technical improvements devised at Royds Mill included the first plant to be installed in England for refining of silver by electrolysis. Heavy contracts for copper, brass, cupro-nickel, silver/copper alloys and silver solders during the 1914/1918 war led to further extensions to plant and buildings at Sheffield, London and Birmingham.

During the 1939-45 war, Government Supply Departments, Royal Ordnance Factories and producers of munitions became the company's main clients.

A difficult trading period in the 1950's necessitated reorganization and under the present chairman, Robert Jardine, the company broadened its trade, forming an agency in Italy and an associate company in Cairo as well as acquiring subsidiary companies in London and Birmingham. The light engineering and electrical and allied trades came within the company's sphere as well as the production of thermocouple wires for the steel and other industries; to meet the needs of peacetime industry, traditional activities have been greatly expanded and new ones added, including the production of non-ferrous ingots made to strict specifications. Silver solders have become essential to the automobile, aircraft and engineering industries while contacts of silver or other precious metals are in general use in electrical and electronic equipment from shavers to satellites.

Products of this company which started in such a small way go all over the world.

STEEL, PEECH AND TOZER TO INSTAL BISRA AUTOMATIC CONTROL EQUIPMENT

STEEL, PEECH AND TOZER (a branch of the United Steel Companies Ltd.) are installing a BISRA Automatic Power Input Controller (" APIC ") on their 5-ton furnace.

The use of large electric arc furnaces for the bulk production of steel is increasing; for instance, Steel, Peech and Tozer announced recently that their 21 open-hearth furnaces are to be replaced by six 110-ton electric arc furnaces. This will be the largest electric steelmaking plant in the world.

WORLD'S LARGEST TRANSDUCTOR

GRESHAM Transformers Ltd., Twickenham Road, Hanworth, Middlesex, have just built what is believed to be the world's largest electro-magnetic control system or transductor.

This equipment, which weighs over 20 tons, will be used in conjunction with germanium rectifiers manufactured by Westinghouse Brake and Signal Co. Ltd., to control an output current of 12,000 amperes.

It is to be used for research work in Holland. The value of the order is £17,500.

BRITISH LUBRICANTS ON SHOW IN NEW YORK

ROCOL LTD., Rocol House, Swillington, Nr. Leeds, were the only manufacturers of specialized lubricants for industry and automobiles in the British Exhibition held in New York from June 10 to 26, 1960.

The firm took a prominent position at the exhibition with a stand of 500 sq. ft. area. To ensure that technical and commercial negotiations could be finalized speedily, top-level personnel in attendance at the stand included Mr. F. G. Wayman (chairman and managing director), Mr. E. J. G. Wayman (export director), Mr. J. C. Gershon (sales director) and Mr. D. E. Burton and Mr. P. Kettlewell (technical sales engineers).

The attendance of Rocol at this exhibition emphasized the firm's activities in the development and manufacture of molybdenum disulphide lubricants.

The firm has also developed a number of other specialities, including the R.T.D. compound, which has been adopted by many engineering machine shops throughout the world as a standard cutting compound for difficult machine operations, especially those containing titanium, alloy steels and other advanced engineering materials.

AMERICAN MAGNESIUM CHIEFS VISIT QUINTON

THE Magnesium Association of America, which held its Spring 1960 meeting at Park Lane Hotel, London, visited Birmetals Ltd. at Woodgate Works, Quinton, Birmingham. Amongst the visiting party were representatives from United States, Canada, France, Germany, Italy, Norway, Sweden, Switzerland and Holland, all having a common interest—magnesium, its production and uses.

The association held its meeting in Britain this year following an invitation extended by the Magnesium Industry Council. The chairman of the council is Mr. Edward Player, managing director of Birmid Industries Ltd. Birmetals Ltd. is the largest single producer of wrought magnesium products in Europe, specializing in rolled sheet and strip, extruded bars, sections and tubes. The visitors were shown the plant at Woodgate Works, including the new Sendzimir Mill—the first of its kind in Europe to handle aluminium alloy strip.

CHANGES OF ADDRESS

IN consequence of the sale of their subsidiary, Fairey Aviation Ltd., to Westland Aircraft Ltd., the address of the Fairey Co. Ltd. from April 11, 1960 has been Woodlands Park, Iver Heath, Bucks. The London office of the company remains at 24, Bruton Street, London, W.1.

ROYCE ELECTRIC FURNACES LTD. have changed their address from June 1 to Albert Drive, Sheerwater, Woking, Surrey, the telephone number being Woking 5401-4.

THE Cambridge Instrument Co. Ltd. state that as from May 1, 1960, its Nottingham office will operate from larger and more convenient premises at the Century Insurance Building, Milton Street, Nottingham, telephone number Nottingham 42612. The resident engineer is Mr. H. G. Starling.

MR. S. B. HAINSWORTH, chairman and managing director of the Pioneer Oilsealing and Moulding Co. Ltd. of Colne, Lancashire, announces that his company have purchased Lower Clough Mill at Barrowford, Nelson, East Lancashire and will enter into occupation later this year. The new premises provide 130,000 sq. ft. of floor space, mostly of the single storey type; they are expected to house the Pioneer Company's growing business for the next few years.

THE head office of Proban Ltd. has moved from its previous address in Royal Exchange, Manchester, to larger and more commodious offices at 34, Princess Street, Manchester, 1.

New telephone numbers for the company are Manchester CEN. 8093 and 8094.

THE Industrial Fan and Heater Co. Ltd., one of the members of the Simms Group of companies, have moved their London headquarters from Barnet to Remax House, Alfred Place, London, W.C.1. Telephone number, LANgham 9561.

DYMET ALLOYS LTD., who specialize in the production and manipulation of tungsten carbide, have now completed their move from Croydon to Camberley, Surrey. Their new address is Frimley Road, Camberley. (Tel. 4433/4.)

Dymet is an associate company of Rockweld Ltd., arc-welding equipment manufacturers, who will also move to Camberley later this year.

WATER TREATMENT PLANT FOR NEW ZEALAND

DEMINERALIZATION plant valued at approximately £20,000 has been installed by the Belco Division of Bogue Electric Manufacturing Co. of America to purify the boiler feed water of the Taswan Pulp and Paper Co. in New Zealand. Located at Auckland and drawing supplies from the Tarawera River near the mill site, for the steam supply and distribution system, the company was faced with the problem of purifying the river water which had an average mineral content of approximately 290 ppm with a soluble silica content of 60 ppm.

The hot lime Belcolite system was chosen to make a reduction in effluent hardness, a decrease in chemical control sensitivity, a reduction in boiler internal treatment and reduced blow down. This system operates at high temperatures and chemical reactions are completed rapidly with low excess of reagents. This enables the size of equipment to be reduced and by employing lime MgO and salt, operating costs are kept to a minimum. Head Wrightson-Belco demineralisation plant and equipment are installed in many parts of the world, large and small, on land, sea and in the air.

DEMONSTRATION VAN FOR PRESS BRAKE

THE Broadway Equipment Ltd., Parway House, 194-196, Finchley Road, London, N.W.3, have fitted out the van shown in the accompanying illustration with a 25-ton " Promecam " hydraulic bending and folding press brake recently introduced into this country by them and made under licence for them by Baker, Perkins Ltd., of Peterborough. These machines feature a sensitively controlled upstroking beam and the complete elimination of stress and distortion on both press and tool by the incorporation of an overloading safety device. Other characteristics are adjustment devices to vary the stroke of the press and the pressure, automatic horizontal alignment of the upstroking beam, a cut-out safety device to prevent excessive deflection of the beams, means of accurate and speedy tool change and a sensitive inching control for setting up. The range extends from 25 to 240 tons, providing for bending lengths up to 13 ft. 6 in. and a heavier press of 350 to 400 tons is in process of development.



LONDON FIRM CELEBRATE CENTENARY

Specialists in Perforated Sheets

THE firm of W. Barns and Son (Holloway) Ltd., reaches its centenary this year. William Barns, the founder, set up business at Euston Road in 1860 as a metal merchant and white-smith, having been apprenticed to this latter trade at the age of 15. His son, William Christopher, joined the firm in 1877 and by this time the business had expanded to include the manufacture of ship's, memorial, and other nameplates. Having previously been merchants of imported perforated materials, they now entered into the manufacture of perforated sheets and plates, special attention being given to the manufacturing of perforated zinc, then much in demand as fly-proof material. New and larger premises had to be found and in 1905 the plant was moved to Globe Works, Queensland Rd., Holloway.

During two world wars, W. Barns and Son provided a round the clock service on Government contracts. At the conclusion of World War II an extensive programme of repairs and replacement of machinery took place. The family is now represented in the third generation by Margaret, daughter of W. C. Barns, who is chairman of directors. Her husband, Mr. J. L. Guermonprez and Mrs. A. E. Barns form the rest of the board of directors of W. Barns and Son (Holloway) Ltd., which became a private company in 1954. Last year the factory was again considerably enlarged and this together with the introduction of new and up-to-date plant enabled them to undertake the manufacture of perforated metals of every description and also plastics, leather, paper and hard-board. A great number of the specialized machines were developed and designed by the firm's own engineering staff and assembled on the premises.

BROCKHOUSE FIFTEENTH GOLF TROPHY COMPETITION

MR. JOHN L. BROCKHOUSE, chairman and managing director of the Brockhouse Organisation presenting the winner's trophy to Mr. W. H. B. Horne of Dangerfield and Co. Ltd., Darlaston, at the group's fifteenth annual golf tournament held at Sandwell Park Golf Club, West Bromwich on May 20. The runner-up was Mr. L. Fletcher of Northern Aluminium Co. Ltd., Birmingham, captain of Sandwell Park Golf Club and third was Mr. C. B. Prentice of Hall and Co. Ltd., Croydon.



A.D.A. ELECT NEW PRESIDENT

AT the recent annual general meeting of the Aluminium Development Association at 33, Grosvenor Street, London, W.1, the retiring president, Mr. Rudolf Hahn, presented the annual report. He noted that the continuing progress of the association had been very satisfactory, with much work completed on the new three-year programme initiated during the year under review. Despite difficulties, such as the printing dispute, the general level of activity showed a further increase over previous years, and the high standing of the association was acknowledged both at home and abroad.

Mr. W. Brining, F.C.A., was elected president of the association for the period 1960/61. Mr. Brining represents the Almin Group of Companies on the A.D.A. Council. He joined the Almin Group as secretary on its formation in 1945, having previously been the secretary of International Alloys Ltd., and became a director of Almin Ltd. in 1952. Mr. Brining is also a director of six of the subsidiary companies of Almin Ltd.

Mr. R. Hahn, who represents the Association of Light Alloy Refiners and Smelters Ltd. on the A.D.A., was elected vice-president for the ensuing year.

INSTITUTE OF METALS LECTURE

THE Institute of Metals announce that Professor Linus Pauling of the California Institute of Technology has accepted an invitation to give a lecture during his visit to this country, His subject will be "The Structure of Metals and Intermetallic Compounds" and the lecture will be delivered at the Royal Institution, Albemarle Street, London, W.1, at 6.30 p.m. on Monday, July 25, 1960. No tickets are required and visitors will be welcome.

Visitors From 61 Countries Attended I.E.A. Exhibition

FINAL attendance figures at the Instruments, Electronics and Automation Exhibition which closed at Olympia on May 28, were 75,276. Of these, overseas visitors totalled 4,015 from 61 different countries.

Home and overseas representatives of newspapers, trade and technical journals, radio and television who attended the Exhibition totalled 529.

APPOINTMENTS and STAFF CHANGES

Mr. Norman Ellyard Langdale, A.M.I.Mech.E., M.I.Prod.E., M.R.S.T., education officer of **Imperial Chemical Industries Ltd.,** Milton Works, has been seconded by I.C.I. to perform the duties of director of practical training and placement at the **College of Engineering and Technology, Delhi,** for two years, under the Technical Co-operation Scheme of the Colombo Plan. This college is being established to ensure an adequate supply of technical personnel to meet the needs of India under the Five Year Plans and is being equipped, in part, from a fund subscribed by British Industry.

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Mr. F. A. S. Wood has been elected chairman of the **Croda Organisation** to succeed the late Sir Edward Crowe, K.C.M.G., and also retains his post of managing director of the company. Mr. Norman Townend, F.C.A., has also been elected a director of the company.

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Sir James Doak, who has been associated with Fenner's Indian enterprises for a number of years, has joined the board of **J. H. Fenner and Co. (Holdings) Ltd.,** the Hull firm of mechanical power transmission engineers.

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The Minister of Power has appointed Mr. A. J. Peech to be a part-time member of the **Iron and Steel Board** in place of Mr. N. H. Rollason, whose appointment expired on May 31, 1960. The Minister has also appointed Mr. A. H. Wilson, F.R.S., to be an additional part-time member.

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Richard Thomas & Baldwins Ltd. announce that Mr. E. Pinches, general manager (engineering), has asked to be released from his executive responsibilities owing to illness. After a rest, which he is taking on medical advice, he will be available in a consultative capacity. In consequence Mr. W. O. Campbell Adamson will be responsible for management and co-ordination of all constructional activities and administration as well as for operational management of Spencer Works, Llanwern. Mr. R. A. Lake, formerly assistant general manager (engineering) at Ebbw Vale, has been appointed chief engineer of the Spencer Works, responsible to Mr. Campbell Adamson.

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Mr. R. E. Powell, former president for 20 years of **Aluminum Co. of Canada, Ltd.,** the principal subsidiary of **Aluminium Ltd.,** has resigned as a senior vice-president of Aluminium Ltd., and was named honorary chairman of Aluminum of Canada Ltd. Mr. Powell, who has served 50 years in the industry, remains a director of Aluminium Ltd. and Alcan. Mr. Edwin J. Mejia, chief sales management officer, was appointed a senior vice-president of **Aluminium Ltd.**

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The engineering group of the **General Electric Co. Ltd.** of England announces the appointment of Mr. J. L. Orme, A.M.I.E.E. as deputy chief engineer for the London, Eastern, and Southern Areas. It will be recalled that Mr. E. W. Molesworth was recently appointed Chief Engineer for the same Areas.

Mr. Orme was educated at Trent College, and after joining G.E.C. as an apprentice in 1920, was nominated by the company for a scholarship at Birmingham University. He returned to Witton Works and later spent three years as assistant branch engineer at the company's cardiff branch.

In 1928 he moved to the head office of the company and later was appointed chief assistant to the manager of Central Stations department, Mr. G. H. Mann, who retired on January 31 last. Although in his new appointment Mr. Orme will be associated with all the engineering activities of the company, his main interest will still be in the supply industry in which he is well known.

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Mr. W. Lionel Fraser, C.M.G., has been appointed the first president of **Babcock and Wilcox Ltd.** Sir Kenneth Hague has become the chairman of the board and Sir Reginald Verdon Smith the deputy chairman.

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The board of **The Wolverhampton Metal Co. Ltd.** have appointed Mr. F. W. James and Mr. K. R. H. James as joint managing directors with Mr. A. M. Anderson.

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Mr. W. G. Hadley, who has had many years' experience as a machine tool sales engineer with A.B.M.T.M. and previously E. H. Jones (Machine Tools) Ltd. has now joined the **Rockwell Machine Tool Co. Ltd.** in a similar capacity, operating in the North of England from their Stockport office.

* * *

Crompton Parkinson (Stud Welding) Ltd. announce the appointment of Mr. J. R. Davis as sales manager in succession to Mr. R. W. Taylor.

Mr. Davies comes to his new post from Expert Heat Treatments Ltd. where he was sales director. He was previously, for 7 years, chief sales engineer in Cooper and Turner Ltd., of Sheffield, well-known in the welding industry as makers of electrodes. He entered the welding industry soon after the war through Lincoln Electric Co. Ltd., who were formerly associated with the sale and service of Nelson stud-welding equipment in this country.

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Mr. Eric Greenwood, general manager of **Modern Machine Tools Ltd.,** and **Precision Machinery Services Ltd.,** Coventry, has been elected to the board of directors of both companies, of which Mr. P. E. Verrall is the managing director.

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The directors of **Manley and Regulus Ltd.** have appointed Mr. Graham Henshaw Edwards of 16, Parkdale Court, Tettenhall Road, Wolverhampton, as a director of the company.

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Jessop-Saville (Small Tools) Ltd. of Portland Street, Sheffield 6, announce the appointment to the board of four new directors—Mr. J. R. Bottomley, Mr. E. Garlick, Mr. D. Milne, Mr. J. F. Wallace.

(*Continued in page* 547)

Dowding & Mills Ltd. Bordesley, Birmingham 12, announce the following appointments:—

Mr. P. L. Hollings, London manager, has been appointed a company director, as from May 23, 1960.

Mr. W. L. Henderson, A.M.I.E.E., previously London sales manager, has been appointed Southern area sales manager.

Mr. H. Glover who recently took up the position of Midland Area sales manager, was previously with Pyrotenax Ltd., as Midland Area sales manager.

Mr. A. H. Sockett, formerly owner of Southern Electrical Repairs Ltd., Southampton, will continue as manager of Dowding & Mills Ltd., Southampton.

Mr. J. Buck, formerly of Brownings Electric Co., has been appointed technical engineer to the London branch.

Mr. W. E. Halls, has recently taken up the position of South Eastern Area engineer representative for the London branch covering mainly Kent, Sussex and South-East London.

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Henry S. Wingate, president of the **International Nickel Co. of Canada** since 1942, has been elected chairman of the board and chief officer of the company and Mr. J. Roy Gordon, who has been executive vice-president since 1957 and a director since 1953, has been elected president. Ralph D. Parker, of Toronto, a director since 1957 and vice-president in charge of Canadian operations since 1955, was elected vice-president of the company.

Mr. Wingate succeeds Dr. John F. Thompson, who retires as chairman after having served the company for 53 years, and as chairman of the board and chief officer since 1951. Dr. Thompson becomes honorary chairman and will continue to serve as chairman of the executive committee.

Mr. F. G. PHIPPS



Mr. F. G. Phipps, M.I.P.E., has relinquished his appointment as director in charge of production of **Davy and United Engineering Co. Ltd.** in view of his impending retirement from the company's service on June 30, 1961, and is succeeded by Mr. S. Baker, M.A. (Cantab.), previously works manager of Davy-United Darnall Works.

Mr. Phipps will remain a director of Davy and United Engineering Co. Ltd. and of **Davy and United Roll Foundry Ltd.** and of **Davy and United Instruments Ltd.** Mr. W. Hatcher, previously manager of the machine and erecting shops at **Davy-United's** Darnall Works, has been appointed works manager in succession to Mr. Baker.



Mr. S. BAKER



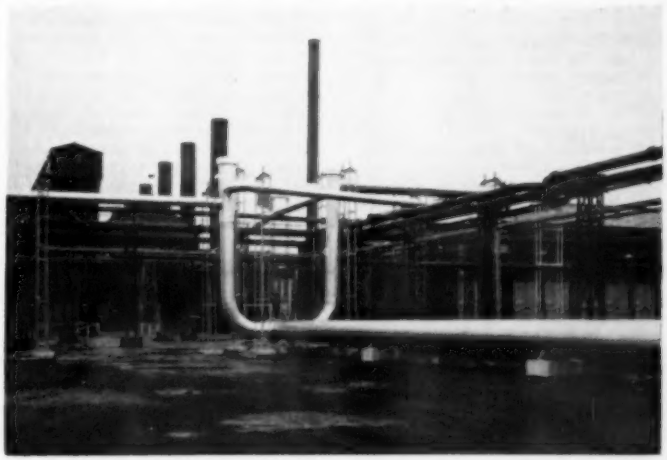
Mr. W. HATCHER

ALUMINIUM CLADDING ON STEAM MAIN

ALUMINIUM sheet has been used to clad a steam main at Spondon to give a lasting, maintenance-free protection from the weather.

The main, a 30-in.-bore steel pipe, was installed to tap steam from a power station and deliver it 2,125 ft. for distribution in the British Celanese Works. The system also includes some 1,300 ft. of smaller-bore branch pipes.

All the insulated pipes in the system were protectively finished with Noral 2SH sheet (0.036-in. thick) supplied in coil form by the Northern Aluminium Co. Seven tons of aluminium were needed in all, but on the largest pipe the cladding weighed only a little over 4 lb. per ft. and its lightness enabled savings to be made in the supporting structure. The insulating engineers, Thomas Cotton Ltd., of Mansfield, Notts., used aluminium because it is economical and easily worked. Lengths of coil were cut to wrap the main circumferentially with a 2-in. overlap joined by "Pop" rivets. Adjacent wraps along the length of the pipe also overlapped by 2 in., but a minimum of permanent fastenings was used at this joint to allow for expansion and contraction.



Books for Your Library

Die-sinking and Engraving Machines. H. C. Town. London, 1959. Machinery Publishing Co. Ltd., National House, 21, West Street, Brighton, 1. Yellow Back Series No. 45. 72 pp. 5s. net.

THIS little book contains a wealth of information on methods of producing dies and detailed description of machines and the trend of development in their manufacture for producing them by other means than hand operation. Considerable trouble has been taken to describe the principles adopted in these machines and the skilled craftsmanship required in their manufacture and it is a little sad to anyone with association with moulding and casting to read in the preface that the justification for the manufacture of the machines is due to lack of hand skill and the use of them will help to dispense with it. This reflection is outweighed by the knowledge that the high quality dies produced results in a nearer perfection finished article which was always the aim of the old-time British craftsman.

Various types of machines referred to include those controlled electrically, electronically and hydraulically for the production of dies and moulds and the last chapter deals with pantograph engraving machines. The book is of general interest outside the die-casting and engraving industries since many of the principles of two-dimensional and three-dimensional contour tracing can and are already used for cutting and finishing machines used in the sheet metal industries.

Zinc: The Science and Technology of the Metal, its Alloys and Compounds. C. H. Mathewson (Editor). 1959. A.C.S. Monograph Series, No. 142, published in New York by the Reinhold Publishing Corporation and in London by Chapman & Hall Ltd. Many illustrations and diagrams. 721 pp. 156s. net.

THE editor of this comprehensive reference book was formerly Professor of Metallurgy and Metallography at Yale University. He has been assisted by 45 specialist contributors and has had the co-operation of the American Zinc Institute. The book covers the metallurgy, chemistry, extraction and uses of zinc in a way that should make the material comprehensible to scientists with little familiarity with the subject. Nearly one-half of the text deals with the geology, occurrence and production of zinc, with sections on the six main production techniques including the new British blast furnace, and there is a chapter on zinc oxide manufacture. Chemistry and physical metallurgy have individual chapters and the rest of the book is mostly concerned with the uses of the metal. Seven sections deal with special aspects of hot-dip galvanizing and others describe zinc plating, zinc spraying, sherardizing and zinc-rich paints. The section on castings carries a full account of the die casting process and that on rolled zinc has a sub-section on photo-engraving. A chapter on zinc as an alloying element covers a wide field, including brasses, light alloys and alloys with tin and silver. A useful selection of phase diagrams is included, taken from Smithell's "Metals Reference Book," 1955 edition. Miscellaneous uses of zinc and its compounds are also dealt with and there is an account of its biological significance. Each chapter has its own bibliography and the book is fully indexed.

It is perhaps ungrateful to find fault with a book that must have demanded great labour to produce, but there is no doubt that it is somewhat unbalanced. Nearly all the contributors are Americans and they have not looked far beyond American publications and experience for their data, as a study of the listed references reveals. It is surprising to find only one reference to chemical analysis, dealing with the determination of impurities in super-purity zinc; even here no details are given, only indications of the techniques that are applicable.

Bearing these limitations in mind, metallurgists, engineers concerned with the preservation of steel, production engineers interested in the manufacture and uses of die castings, chemists working with paints and the numerous other products into which zinc compounds enter, university and technical college lecturers and students will all find the book remarkably comprehensive and readable.

R. L. CHIVERS.

A Guide to Aluminium. 1959. By L. V. Chilton, M.A., F.Inst.P. The Purchasing Officers Association, Wardrobe Court, 146a, Queen Victoria Street, London, E.C.4. or the Aluminium Development Association, 33, Grosvenor Street, London, W.1. 3s. 6d. post paid.

THIS 32 page booklet contains a series of articles by Mr. L. V. Chilton which appeared in "The Purchasing Journal", July-October, 1959 issues with the object of giving Purchasing Officers a background and market view of the many facets of industry which aluminium serves and of the forms in which it is available.

When the information had been brought together it was felt to be of such general interest as to be made available to a wider readership. The booklet, while not pretending to be a comprehensive statement on the subject, will undoubtedly serve as an adequate introduction to it, and will make a valuable addition to educational publications both for teacher and student. The contents include:—

1. Ores and production methods.
2. Properties and methods of use of aluminium and its alloys.
3. Major fields of application of aluminium (including Transport, Building and Structural Engineering, Packaging and Containers, Electrical Food, etc.).

Report of the 44th National Conference on Weights and Measures, 1959, National Bureau of Standards Miscellaneous Publication No. 228, issued December 18, 1959. The Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C. 144 pp. 65 cents.

THE 44th National Conference on Weights and Measures was held in Washington, D.C., June 8-12, 1959. Approximately 500 delegates, representing state and local governments, Federal agencies, trade associations, and business and industry, attended the conference, which was sponsored by the National Bureau of Standards.

In this report, full texts are given of the opening addresses by Secretary of Commerce Lewis L.Strauss; conference chairman C. M. Fuller, County Sealer of Weights and Measures, Los Angeles County, California; A. V. Astin, director, National Bureau of Standards; and Genevieve Blatt, Secretary, Department of Internal Affairs, Commonwealth of Pennsylvania. The bulk of the report comprises committee reports and papers delivered by the delegates, along with a list of the persons attending, the officers of the conference, and the committee memberships.

Subjects discussed include "Communications in Weights and Measures Enforcement," "Moisture

(*Continued in page* 549)

Books for Your Library

(*Continued from page* 548)

Measurement in the Grain Industry," "Weights and Measures in Alaska—the 49th State," "Weights and Measures Administration in France," "The Federal Trade Commission, Its authority, Its Activities," as well as many others.

Gas-Shielded Arc-Welding. The American Welding Society, 33 West 39th Street, New York 18, N.Y. 78 pp., 39 illustrations and 9 tables. $1.50.

GAS-SHIELDED ARC-WELDING describes in detail the group of processes which were originally called Inert-Gas Processes but which were renamed with the development of shielded gases, such as CO_2, which are not inert.

The contents are taken from published and unpublished material from Sections I, II and III of the Fourth Edition of the Welding Handbook. Included in this small, authoritative book are: gas shielded tungsten-arc welding, gas shielded metal-arc welding (including CO_2 welding), cutting, gases, equipment, and cost data. The book is profusely illustrated and photographs, schematic diagrams or charts show every step of the way.

"Gas-Shielded Arc-Welding" is currently being used as a text for an intensive course on the subject presented by the American Welding Society.

Sheet Metal Worker and Coppersmith. March 1960. Issued by the Central Youth Employment Executive. H.M. Stationery Office, No. 97. 2s. net.

OPPORTUNITIES to acquire a skilled trade as coppersmith, sheet metal worker and panel beater are described in this booklet of the "Choice of Careers" series, which also contains descriptions of the crafts of metal spinning and goldsmithing and silversmithing, as well as conditions of employment in these trades.

1958 References on Fatigue STP 9-J. American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pa. 76 pp. self cover, duplicated. $3.50.

THIS list of references to articles published in 1958 dealing with fatigue of structures and materials is a continuation of a series started in 1950. There are 386 references. While the list is extensive it is not exhaustive and is so arranged that the sheets may be cut for filing. Where possible, brief abstracts have been included. All nine reference volumes dating back to 1950 are available for $15.00.

Handbuch Der Grossunternehmen (Manual of Large Enterprises). 1960. Verlag Hoppenstedt and Co., Havelstrasse 9, Darmstadt/West-Deutschland. In 2 volumes. DM 120 complete.

THIS manual contains practical information on more than 11,000 large firms in West Germany and West Berlin, such as Joint Stock Companies, Limited Companies, Limited Partnerships, etc. A special section contains a classification of production groups as well as an alphabetical index of all firms.

ASTM Standards on Metallic Coated Iron and Steel Products. A-5. American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pa. 176 pp., hard cover, $3.50.

THIS 2nd edition is virtually a complete revision of the first edition issued in 1956. Of the 34 standards all but five have been newly added, revised, or have had their status changed.

Among the materials covered are zinc-coated wire, strands, fencing, sheets, pipe and hardwire. Also included are aluminium-coated wire and aluminium-coated iron and steel articles as well as terne-alloy-coated sheets. There are 25 specifications, six methods of test, and three recommended practices.

Engineers and scientists concerned with coated metallic products, corrosion and maintenance will find this compilation useful in their work.

Pensions Scheme for Moon Brothers, Birkenhead

THE Birkenhead firm of Moon Brothers Ltd., makers of steel drum and tin box making machinery, has decided to implement a pensions scheme for its staff of over 100.

The scheme is open to employees aged 21 and over, in the case of male employees after one year's service and after five years' service in the case of females. It is designed to provide an income after retirement at 65. The amount of the pension will be proportionate to the number of years service with the company. Contributions are assessed on the basis of wages, so that a man receiving a basic wage of £10 a week would contribute 6s. 4d. a week and qualify, on retirement, for a pension of £4 15s. for each year's contributions. On this scale a worker would receive a pension of £2 a week for life after 22½ years. In the event of an earlier death the employee's dependants would receive £400.

INSTITUTION OF METALLURGISTS LUNCHEON

THE annual luncheon of the Institution took place on Thursday, May 19, 1960, at the Park Lane, Hotel, London, with the president, W. E. Bardgett, Esq., in the chair.

The guests included Sir Lincoln Evans (deputy-chairman of the Iron and Steel Board), Dr. R. Cockburn (chief scientist, Ministry of Aviation) Dr. Reginald Bennett (chairman, Parliamentary and Scientific Committee) and Mrs. Bennett, Councillor David Cobbold (deputy Mayor of the City of Westminster) and Mrs. Cobbold, Sir Harry Melville (secretary, Department of Scientific and Industrial Research) and Lady Melville, Sir George Thompson (president, Institute of Physics), Dr. J. H. Watson (president Institution of Mining and Metallurgy) and Mrs. Watson, Air Marshal Sir Owen Jones (president, Royal Aeronautical Society) and Lady Jones, and Mr. A. A. B. Harvey, (president, Institute of Metal Finishing) and Mrs. Harvey.

"Research" Awards

THE Scientific Advisory Board of Research, 4-5, Bell Yard, London, W.C.2, have decided to continue the Waverley Gold Medal Essay Competition this year and are inviting entries for the best essay of about 3,000 words describing a new scientific project or practical development; essays will be judged for technical content by specialists in the subject, for clarity of presentation and for style. The board are introducing a new "Application in Industry" essay competition, and candidates, who must be practising scientists under the age of 30, are invited to write an essay of some 5,000 words on practical problems encountered when applying scientific developments to industrial projects. The last date for entries in each case is July 31, 1960.

Publications for Industry

A NEW, larger edition of Keith Blackman's "Heavy Fan Engineering" booklet (Publication No. 25, 24 pages) has now been published and is freely available now to anyone writing to the Publicity Dept., Mill Mead Road, London, N.17 (Telephone Tottenham 4522, Ext. 310). This is a fully illustrated booklet, designed to show the scope of the "Tornado" range of fan engineering equipment in the large and heavy sizes. Individual sections deal with centrifugal and axial fans, blowers and exhausters, ancillary equipment such as air heaters, dust exhaust and collecting plant, and metal structure and fabrications. A further section provides a brief survey of the manufacturing facilities available at the three Keith Blackman Works at Tottenham and Edmonton, London, and Arbroath in Scotland.

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A publication issued by the Imperial Chemical Industries Ltd. Heavy Organic Chemicals Division, Billingham, is a leaflet entitled "Thermex" Heat Transfer Medium. Thermex, which is the first heat transfer medium of its kind to be manufactured commercially in Britain, is a eutectic mixture of diphenyl oxide and diphenyl in the respective proportions by weight of 73.5 per cent and 26.5 per cent, and the combination of its physical properties make it particularly suitable for liquid-phase and vapour-phase heating and cooling in a variety of industrial processes. It has a boiling point of 255° C., a low freezing point of 12° C. and excellent thermal stability over long periods at temperatures up to 400° C. It has high heat transfer coefficients, particularly in the vapour phase, and is non-corrosive, has no toxic effects on humans and presents a negligible fire risk. Thermex operates at low pressures at high temperatures; for instance, at 250° C. it is still in the liquid phase and at atmospheric pressure when steam has a gauge pressure of 565 lb. per sq. in. whilst at 350° C. its working pressure is 80 lb. per sq. in. and the gauge pressure of steam is 2,385 lb. per sq. in. In vapour-phase heating, very accurate temperature control can be achieved simply by regulating the pressure.

Rocol Ltd. of Aldwych, London, W.C.2, who manufacture and supply specialized lubricants and molybdenized lubricants in particular, have issued a booklet entitled "ROCOL—First in Molybdenum Disulphide Lubrication" which shows how molybdenum disulphide is purified and prepared, the results of some of the tests on various types of equipment, and describes its salient properties.

There follows three pages of tables indicating the many Rocol lubricants, the method of applying them, their general uses and temperature and pressure ranges. Eight pages of photographs show a great diversity of application of Rocol lubricants by 24 of Britain's leading concerns; these applications include, *inter alia*, machining, high-temperature applications, gear-box lubrication, fluid control valves, heavy electrical engineering, machine tool manufacture and switchgear maintenance.

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Swale Chemicals Ltd., of 55, Park Hill Road, Croydon, Surrey, have issued a bulletin on their Lakadize BUT.100 coating for structural aluminium which has aroused interest in the building industry. This coating is claimed to provide a high gloss and protection against salt spray, wind and rain, exhaust fumes, has excellent scuff resistance and is non-yellowing. It dries within 30 minutes but is tack-free within 10-15 minutes, so that relatively dust free coatings may be obtained out of doors. Another Swale product is Lakadize EPO which is a tough highly decorative range of epoxy-based lacquer finishes comparing very favourably with electro-chemical processes and suitable for a wide range of articles such as kitchenware and industrial components. It can be applied by dipping or spraying and must be stoved for 20 minutes at 170° C. after application.

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"Paint in Industry," No. 1, published by the Industrial Division of Blundell, Spence and Co. Ltd., 37, Queen Square, London, W.C.1, describes some of the methods used in the application of the surface coatings developed and manufactured at their Industrial Division works on the Slough Trading Estate, Bucks. These air-drying, stoving and cellulose finishes, a large number of which are specially formulated to meet individual requirements, are used for a wide range of products and methods of application include hot and cold spray, electrostatic, dipping, flow-coat, roller-coat and automatic spray. Reference is also made to the production of plastic coated steel and pre-painted steel or aluminium coiled strip, using roller-coating enamels. The Industrial Division of Blundell, Spence and Co. Ltd. was created last November from three wholly-owned subsidiaries, Vulcan Products Ltd. of Slough, John J. Bowater Ltd. of West Bromwich, and Paint Removers Ltd. The 'Blundwagon,' March-May, 1960, which is the House Magazine of the Blundell, Spence Group, refers, among other matters, to the use of emulsion paint for the exterior decoration of 90 aluminium pre-fabricated bungalows at Cheltenham which, in lively colours, has revitalised the former grey monotony.

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The Spring issue of "Siftips," the quarterly magazine issued by the Suffolk Iron Foundry Ltd. of Stowmarket, contains an article describing the method of laying and welding aluminium roofing on the Corby Beanfield Junior School, Corby, Northants, as well as hints on welding problems.

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In the Spring issue of "Copper," the journal of the Copper Development Association, an article by A. D. Fitness describes the importance copper and brass have assumed as "cutting" electrode materials for the spark-machining process. Reference is also made to the recent introduction in this country of copper tiles, comprising 12½-in. plywood squares sheathed with 37 s.w.g. copper, which is a popular method of roofing in Finland. The C.D.A. have also recently issued a new publication No. 57 "Copper Roofing" covering all aspects of copper sheet and strip applicable to roofing.

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"Inco Mond Magazine No. 13," published by The Mond Nickel Co. Ltd., features electrodeposition of nickel for decorative and repair purposes. The article draws attention to a campaign to improve chromium plating by paying more attention to the nickel undercoat, which is expected to raise plating standards in all fields.

Other subjects dealt with include metallic gasket problems, loudspeakers, dyeing machinery, dish washing and vacuum drying.

The publication is obtainable free on request from The Mond Nickel Co. Ltd., Publicity Department, Thames House, Millbank, London, S.W.1.

"I.C.I. Titanium /2," issued by the Metals Division of I.C.I., deals with the physical and mechanical properties of pure titanium and titanium alloys and is well furnished with clearly illustrated tables and graphs; another publication from the Metals Division is "I.C.I. Titanium /4, Fabrication," containing chapters on the use and methods of handling titanium and titanium alloys in machining and grinding operations, hot working, forming, annealing, descaling and surface treatment, welding, brazing and soldering.

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The Imperial Aluminium Co. Ltd.—Impalco—have issued a leaflet illustrating some of the many applications for which aluminium sheet and strip from Impalco Waunarlwydd Works are being used.

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Dawe Instruments Ltd., 99/101, Uxbridge Road, London W.5, in the March issue of "Dawe Digest," describe how the problems of traffic noise and the noises arising in factories, workshops and offices by mechanisation can be solved by the assistance of noise meters manufactured by them. There is also an article on stroboscopic resonance testing at the Croydon laboratories of the Mullard Radio Valve Co. Ltd. using the Dawe Type 1206 Slow Motion Stroboscope and a test forming part of the development programme of the Bristol-Ferranti Bloodhound guided missile using Type 444 Vibration Sweep Oscillator and the Type 1208 Variphase Strobe.

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"Technical Notes" No. 207 issued by The Technical Service Department, CIBA Ltd., Duxford, Cambridge, contains descriptions and illustrations of a number of recent glued timber structures which illustrate the main advantages of this form of construction, namely, that the architect can readily combine structural strength with attractive design and that glued timber constructions are free from corrosion hazards and thus reduce maintenance. Whilst it is often thought that timber constructions increase the danger of fire, this is claimed not to be the case with solid or laminated structures of fairly thick section, but with all types of timber, fire hazards can be reduced by suitable impregnations. The April issue, No. 208, is devoted to an article describing the use of "Araldite" in the Napier de-icing equipment for aircraft consisting of a pattern of sprayed metal heating elements embedded between two layers of "Araldite" resin.

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The latest edition of "H-VW-M Plating and Polishing News," which is published quarterly by Hanson-Van-Winkle-Munning Co., Church Street, Matawan, N.J., is now available to all members of the metal finishing trade; it is in its 13th year of publication and readers are able to keep abreast of the times with this four-page brochure featuring the latest equipment, supplies and processes through the research and development laboratories of H-VW-M, which is among the largest manufacturers of electro-plating equipment in the world. Future copies of the publication may be obtained by direct application to the company.

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Kieserling and Albrecht, machine tool manufacturers of Soligen, Germany, have issued a wallet containing well illustrated and informative brochures covering the wide range of machines and presses manufactured by them; these include high duty draw benches for the production of tubes and bright bars, centreless bar turning machines, combined bar straightening and polishing machines, tube and pipe straightening machines, strip straightening and cut-off machines, bolt blank cropping machines, hot bolt headers, horizontal and vertical forging machines for pressures up to 2,000 tons, a variety of presses for blanking, stamping, drawing, pressing and trimming work and a tube finishing plant having a capacity of 3,000 ¼-in. tubes per hour in which tubes are chamfered, pressure tested, threaded at each end and the sockets finally screwed on. Many of the machines are designed for semi-automatic or automatic operation.

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B.S.I. News for April, issued by the British Standards Institution of 2, Park Street, London, W.1, refers to a Special Issue—B.S.1224; 1959, "Electroplated Coatings of Nickel and Chromium," consisting of a working drawing of the B.N.F. sulphur dioxide corrosion test cabinet; copies of the drawing which can now be obtained, price 5s.

* * *

A recent issue of "Machine Tool Review," published by Alfred Herbert Ltd. of Coventry refers to the success of the new Ardoloy Grade AK which, it is claimed, has proved superior to tungsten-carbide for cutting tools due to its immunity to chipping of the cutting edge and its better balance between hardness and brittleness than any other material. The article is well illustrated and supported by quoted examples of field tests.

Another well illustrated article is an account of the production by the Shipston Engineering Co. Ltd. of the Norgren range of compressed-air equipment and the Sundstrand range of compressed-air equipment sanders under licence from the American companies. The Norgren range of equipment includes compressed-air filters, pressure regulators and oil-fog lubricators, the principle of the latter being to introduce a small amount of oil into the compressed air stream as a fine mist, thus lubricating parts which usually receive little or no attention.

The journal also contains information on the advantages of the optical projection system of production inspection in industry and a detailed description of the No. 230X High Precision Surface Grinding Machine produced by the Lumsden Machine Co. Ltd. of Gateshead.

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Fisherlow Magazine Vol. 6, No. 1, issued by Fisher and Ludlow Ltd., Bordesley Works, Birmingham 12, contains some well illustrated articles describing examples and cases of employment of their wide range of open mesh steel road and surface flooring, shelving, and belt, roller and towing conveyors. One instance where conveyors have been used to create an efficient materials handling system is at the Ignis organization factory at Comerio, Italy, which specializes in the enamelling of frames and components and has a Flowmaster conveyor track of 656 yards long and two Flowlink overhead chain link conveyors, the tracks of which total 1,100 yards. More than 1,500 tons of this firm's open mesh steel road surface have been used on the new 1¼-miles long Ogdensburg-Prescott Bridge over the St. Lawrence Seaway; this bridge decking can carry an axle load of 32,000 lb. with supports at 3-ft. centres, and has many design advantages as well as savings in initial cost, erection and subsequent maintenance.

* * *

The 1960 edition of the "Trico Continental Driving Guide is now available and can be obtained from Trico-Folberth Ltd., Great West Road, Brentford, Middlesex. The guide contains in condensed form, charts for converting distances and speed from kilometres to miles, tyre pressures from pounds per square inch to kg/cm², temperatures from centigrade into fahrenheit and petrol consumption in litres per 100 kilometres.

NEW COMPANIES

"Ltd." is understood, also "Private Co." Figures — Capital, Names — Directors, all unless otherwise indicated.

BAYLISS ENGINEERS (LEAMINGTON SPA), 13, Binswood Avenue, Leamington Spa. March 3. £8,000. *To take over bus. of jig and toolmakers and precision and general engineers carried on as "Bayliss Engineering Co." etc. John A. Bayliss and Teresa M. Bayliss, Hilda Law.*

DYAS METALS. March 31. £5,000. *To carry on bus. of metal merchants. Albert T. Dyas, John C. Morris.*

CROWTHER AND GEE, Firth Street, Huddersfield. April 4. £6,000. *To take over bus. of brass and non-ferrous founders. Austin F. Holroyd, George Holroyd and John M. Holroyd.*

CHEAPSIDE ENGINEERING, 30a, Cheapside, Hanley, Stoke-on-Trent. April 5. £1,500. *To take over bus. of precision tool and dyemakers in ceramic dust and sheet metals, press tools, arc and acetylene welding carried on at Hanley by G. Johnson. George Johnson.*

GUIDE ALLOYS, York Street, Audenshaw, Lancs. April 6. £1,000. *To enter into agreement with Benjamin Taylor and to carry on bus. of manufacturers of and dealers in metal ingots, metal and machinery merchants, etc. Benjamin Taylor.*

S.R.S. GRINDING, 248/250, Belgrave Road, Birmingham, 12. April 7. £2,000. *To carry on bus. of precision grinders and tool manufacturers, etc. Bertram Sturm, Leslie H. Rudge, Thomas Sugden.*

NOOK TOOLS, Evans Street, Hurst, Ashton under Lyne. April 21. £1,000. *To take over bus. of a toolmaker carried on by R. Charlesworth. Ronald Charlesworth, Eric Charlesworth.*

P. D. SAGE, 1, Birch Street, Wolverhampton. April 21. £10,100. *To carry on bus. of manufacturers of metal products, engineers, etc. Cyril E. Marshall, Peter D. Sage.*

F. AND T. McBRIDE, 2, Knotts Lane, Canterbury. April 22. £2,000. *To take over bus. of sheet metal workers. Thomas McBride, Frank McBride and Winifred H. McBride.*

HORNES (PECKHAM). April 22. £100. *To carry on bus. of steel and metal merchants, manufacturers of and dealers in steel and metal products, leather and plastic goods, etc. Dora and Eleanor Horne.*

PRECISION JIGS, 79, Caterham Avenue, Barkingside. April 25. £100. *To carry on bus. of electronic and automation engineers. Stanley C. Hoare and Ashley C. Hoare.*

STEPHEN PLANT COE., Silver Street Works, Bollington, nr. Macclesfield. April 28. £1,000. *To carry on bus. of metal polishers and light industrial metal workers, etc.*

JAMES J. WALSH AND SONS, Manchester. April 28. £1,000. *To carry on bus. of manufacturers of and dealers in engineers' welding and cutting equipment, etc. James Walsh and Audrey Walsh.*

METAL FABRICATIONS (PUDSEY), 27, John Adam Street, W.C.2. £2,000. *James R. Williams, Henry B. Baker.*

GOLDS HILL STEEL STOCKHOLDERS, Victoria Works, Pikehelve Street, Golds Hill, West Bromwich. April 28. £1,000. *To take over bus. of steel stockholders carried on by Thomas Patrick Macdonald. Thomas P. MacDonald and Mrs. E. G. MacDonald.*

AVENTI ENGINEERING, Barncroft Road, Farnworth, Lancs. April 29. £3,000. *To carry on bus. of fabrication engineers, sheet metal workers, etc. Arthur Entwistle, Stanley Avison, Albert Dobson.*

DESIGN IMPROVEMENTS, 25, Portland Rise, N.4. May 2. £100. *To carry on the bus. of designers, toolmakers, engineers, etc. David E. Crauford Taylor and Ann M. Crauford Taylor.*

From the Register compiled by Jordan & Sons Ltd. 16, Chancery Lane, London, W.C.2.

Films

THE United Steel Companies Ltd. have announced the availability of two new colour films produced for them by Wallace Productions Ltd. in 16 and 35 mm. sizes. "Stone into Steel," which is 3,384 feet long and runs for 37 minutes, is a commentary on the Appleby-Frodingham Steel Co., whose works in Scunthorpe is the largest single unit in the United Steel group, and "Out of the Forest," which is 2,700 feet in length and runs for 30 minutes, was filmed mainly at the Sheffield works of the United Coke and Chemicals Co. Ltd., who are primarily engaged in the carbonization of coal to produce metallurgical coke for the manufacture of iron at the Appleby-Frodingham Steel Co's. works at Scunthorpe, but also includes scenes at steelworks, tar distilleries and other locations interested in the derivation and application of chemicals resultant from the carbonization of coal.

THE Lancashire Dynamo Electronic Products Ltd. of Rugeley, Staffordshire have introduced a new film, "Invitation to Prosperity" which was shown at the Instruments, Electronics and Automation Exhibition at Olympia and following the initial showing at the National Film Theatre in London is to be shown in the main industrial centres in the United Kingdom; it is intended that copies will be available for general distribution from all the leading film libraries in the early autumn of 1960. The theme of the film illustrates the way in which automatic control can help industry towards greater and more profitable production and is intended to bring the story to all levels in industry. The Central Office of Information have drawn attention to a similar film, "Push Buttons and People," which is available from the Central Film Library, Industrial Section, Bromyard Avenue, Acton, W.3, in which the president of the American Union of Automobile Workers speaks before a Senate of Enquiry on the social and economic effects of automation. Among other films that can be hired or borrowed from C.O.I. are the "Art of Soft Soldering" and "Production Miracles through Controlled Air Power." The current "Films for Industry" catalogue and its Supplement No. 1 is now in publication and can be obtained direct from C.O.I.

THE National Joint Committee on Materials Handling, a co-ordinating committee of professional and other non-trading research and development associations interested in materials handling, published in May, 1958, a list of films on materials handling, giving size, running time, a brief synopsis, and the source from which each may be obtained.

The Committee's opinion that, in making this information available in a consolidated form for easy reference, it was providing a service to industry, has been fully confirmed by the large number of requests for the list received.

The list has now been revised and considerably augmented to include particulars of approximately 100 films. Copies, price 2s. post free, may be obtained from the Secretary, National Joint Committee on Materials Handling, 32, Watling Street, London, E.C.4. Telephone: CITy 7045.

New Plant and Equipment

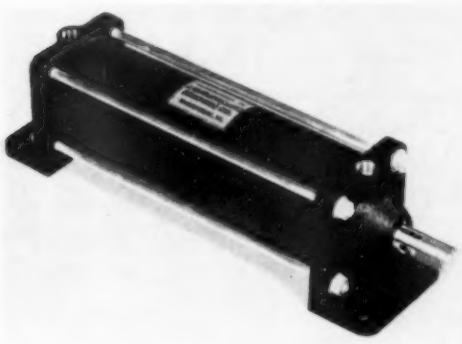
Air Cylinders

A NEW range of air cylinders available in 1½ in., 2 in., 2½ in. and 3 in. bore is being marketed by J. Broughton and Son Ltd., Kings Norton, Birmingham.

Features are: four tie rod construction; cylinder barrel of high-quality seamless drawn brass tube; end covers of high-pressure brass or gun metal; stainless-steel piston rod; aluminium piston plates; and deep section cup washers to provide long life and efficient sealing.

A replaceable sintered bronze piston-rod bearing is fitted in the end cover together with a piston rod pressure seal. The cylinders are finished to a high standard and are available for neck mounting, foot mounting and trunnion mounting, and can be supplied non-cushioned or cushioned, the latter being provided with fine adjustment needle valves for efficient control. Fig. 1 shows a foot-mounted cylinder.

Fig. 1.—Foot mounted air cylinder



Vacuum Handling Equipment

FIG. 2 shows an example of lifting equipment using mechanically created vacuum suction pads in place of slings and hooks which was exhibited for the first time at the Mechanical Handling Exhibition at Earls Court. The equipment is produced by a Scottish firm, Vac-U-Lift (Great Britain) Ltd. of Glasgow, who claim that this form of lifting is safer, faster and cheaper than the conventional type of lifting appliance. The equipment is produced in a variety of designs, sizes of beams and types of pads to cope with a wide range of weights and materials; a hand model is produced with a hand release for small sheet articles to save injury to the operator's hands. The gripping power of the Vac-U-Lift system is achieved when the air inside the pad is withdrawn upon contact with the material to be handled and instantaneous release is accomplished by the introduction of air into the pad, thereby eliminating the vacuum. Both vacuum and air is continuously available through a 5-way solenoid valve operated by push-button control and is produced by an electric, hydraulic, gasolene or air-driven motor operating a rotary-vane type vacuum pump. Visual indication that it is safe to lift is given to the operator by a red or green light on the beam and in the crane cabin. Even in the event of power failure the Vac-U-Lift continues to hold the load and a dual safety factor is a built-in safety reserve of vacuum which is maintained by the 5-way valve.

Aluminium Melting and Holding Furnaces

A DRY hearth, aluminium melting furnace with a companion holding furnace, both of American design, are now being made in this country by the Electric Resistance Furnace Co. Ltd., Weybridge, Surrey.

The two furnaces form a central installation for melting up to 500 lb. of aluminium an hour for die casting, mould and sand casting, and for recovering aluminium from scrap. The metal can be ladled direct from the holding furnace or tapped off and delivered hot to other holding furnaces.

The aluminium scrap is charged into the furnace hopper where pre-heating begins. As it moves into the furnace it collects on and above a sloping, dry hearth of silicon carbide and is contained in a vertical cylindrical muffle heated externally by silicon carbide elements. The molten metal is directed by the hearth through a covered trough where it runs out without overheating to be maintained in the holding furnace at the precise temperature required.

To prevent oxidation, the aluminium is melted and held at temperature in an atmosphere of high purity, dry nitrogen. Oxide present in the scrap collects on the hearth and can be raked out through a plug door at the back. This door can be used for inserting ingots.

The furnaces are ruggedly constructed and heavily heat insulated. Elements are easily and quickly replaced after their normal long life. Installations are supplied complete with temperature control gear and the furnaces can be arranged for operation on standard single- or three-phase supplies. The melting furnace is rated at 100 kW., the holding furnace has a capacity of 1,500 lb. and a rating of 20 kW.



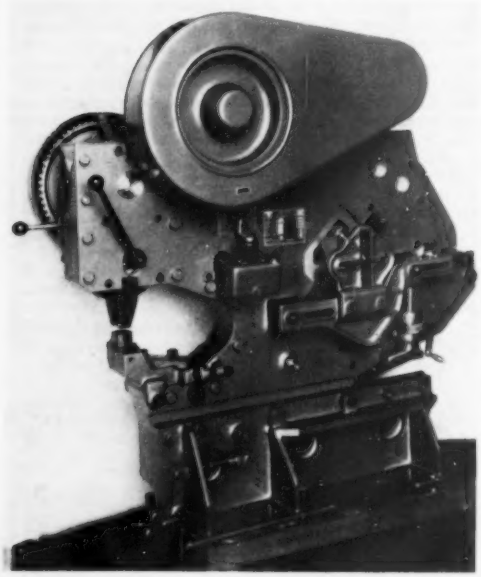
Fig. 2.—2-ton capacity vacuum handling equipment for sheets

Punching and Shearing Machines

THE Valdarno Universal Punching and Shearing Machine illustrated in Fig. 3 is one of a range of eight models giving capacities for shearing and punching sheet up to 1 in. in thickness, cropping round bars up to 2¾ in., tee sections up to 7½ × ¾ in., and angles up to 8 in. × 4 in. by ¾ in.; sheet, angles and tees can be notched up to ¾ in. section thickness and special blades can be provided to cut and punch double-tees and channels. The machines are constructed from extra thick steel plates of high tensile strength and all models are fitted with the Valdarno safety overload friction disc. The mounting of the flywheel is specially designed for the minimum vibration and load on the bearings and the gear-train is so arranged to ensure true meshing even under heavy loading so that the machine is smooth running. The speed has been calculated down to the realistic speed of the operator which has the advantage of increasing the power applied to the work. Controls permit single stroke or continuous operation up to 40 strokes per minute. Standard electric driving motors, 400-v. 3-phase, are fitted together with a star delta starter and lubrication is fed to the working parts through a system of copper tubing from a central pump.

The manufacturers are Valdarno S.A. of Milan and the sole distributors in this country are the Sharston Engineering Co. Ltd., Manchester 22

Fig. 3.—Punching and shearing machine



Automatic Voltage Compensator

SCIAKY BROS., INC., 4915 West 67th Street, Chicago, Illinois, announce a new form of heat control for their resistance-welding machines of the Dekatron type. Designed to eliminate excessive voltage fluctuations which produce inconsistent welding, the AVC automatically shifts the phase of firing pulses which control the heat regulating function of thyratrons within the power recifier cabinet. By advancing the phase of these pulses when line voltages surge or drop within plus or minus 10 per cent, the weld current can be held to plus or minus 2 per cent, at any given setting on the control dial. Full correction is made within one-third of the cycle. An optional item consists of a small AVC cabinet which is mounted on top of the rectifier cabinet. A modified weld phase shift chassis replaces the existing one. A plug box is provided which is installed within the rectifier cabinet, and has all the necessary cables, wires and plugs for easy connection.

Air Blast Tunnel Burners

A NEW range of tunnel burners has been designed by Barlow and Whitney Ltd., 2, Dorset Square, London, N.W.1., which they claim give greatly improved heating rates due to the high velocity and high temperature of the discharge gases.

They are suitable for many direct local convection heating applications such as in forge work, billet heating and glass polishing, apart from installation in boilers, furnaces, ovens and similar industrial plants employing the principle of jet recirculation. The burners are of compact design incorporating their own combustion chambers and using air blast injection from a simple centrifugal blower to entrain gas at atmospheric pressure.

The series " B " circular discharge models have metal-cased combustion tunnels for low and mediun temperature applications (*e.g.*, to 500° C.) and series " C " slot discharge models for high temperature applications (e.g., to 1,500° C.) have refractory cased combustion tunnels suitable for setting in brickwork. Capacities range from 0.5 to 10.0 therms per hour on town's gas (475 B.T.U. calorific value) when operating on 15 in. w.g. air pressure. Larger and special models and units for use with butane and other gases can also be supplied.

Metal Deck Roof With Coloured Plastics Soffit

THE Rubberoid Co. Ltd., Commonwealth House, 1-19, New Oxford Street, London, W.C.1, are now marketing, under the name of " DecoRdeck," a range of insulated metal deck roofs with permanent-colour plastics soffits made from a laminate of galvanized steel sheet and coloured polyvinyl chloride. The new units are abrasion-resistant, incombustible, easily cleaned with soap and water and available in light green, light blue, yellow, red, grey, cream and white ; other colours can be supplied by arrangement.

It is claimed that it is impossible for the P.V.C. and the steel sheet to delaminate and stability is assured in temperatures of up to 110° C., and for limited periods up to 180° C.

Lightweight Hammers

THREE new lightweight models have been added to the range of Stanley hammers, a 6-oz. Warrington pattern hammer (No. W.00,) a 3½-oz. Warrington pin hammer, sometimes known as a telephone hammer (No. CP/3½), and a 4-oz. ball pein pin hammer (No. BP/4). All have the Stanley " Evertite " processed top grade ash handles which are pre-shrunk and treated to ensure that the heads will not come loose.

The highly polished, drop forged heads are individually hardened and tempered on faces and peins and rim chamfered. With the addition of the CP/3½ and the W.00 there is now a complete range of six Stanley Warrington pattern hammers, from 14 oz. downwards. The hammers are manufactured by Stanley Works (G.B.) Ltd., Rutland Road, Sheffield, 3.

Flanging, Beading and Seaming Machines

FIGS. 4 and 5 illustrate two new Rhodes machines recently designed and supplied to meet specific requirements.

Fig. 4 shows a flanging and beading machine of the squeezer type for rectangular can bodies and Fig. 5 is a double seaming machine for the tops and bottoms in which the can remains stationary during the seaming operation. The incorporation of compressed air equipment gives sequential operation by which the machine starts as soon as the can is in the correct position and the feeding of cans to the iregular double seaming machine is facilitated by the tilting motion of the bottom pallet.

The makers are Joseph Rhodes and Sons Ltd., Grove Ironworks, Wakefield, Yorks.

Fig. 4.—Squeezer type flanging and bending machine for rectangular cans

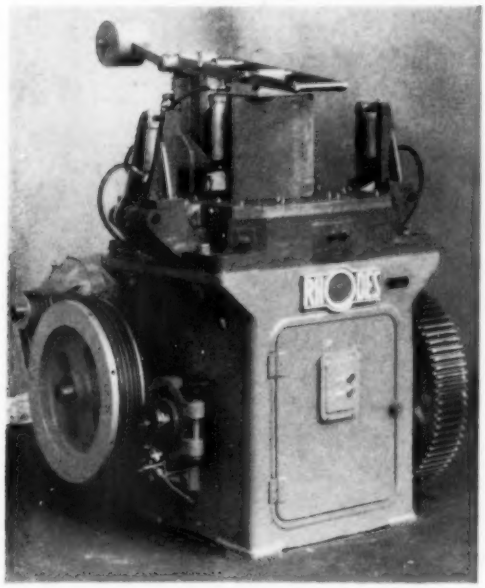




Fig. 5.—Irregular double-seaming machine

High-Precision Temperature Controller

A FULLY transistorized printed circuit amplifier-relay for use as a stable, sensitive, temperature controller, has been introduced by Honeywell Controls Ltd.

With the appropriate thermistor temperature sensor, the R7079/7081 Versa-Tran can be used for control in the range of −60° to +500° F. with a differential of 1.5° F. or 0.3° F. depending on the model. Control is very stable and errors due to ambient temperature conditions are easily compensated for by means of a calibration dial. Wiring between sensing element and relay need not be shielded ; the bridge presents no capacity balance problems ; ordinary 18 s.w.g. two-conductor insulated cable will suffice. The control, which incorporates the load relay, can be used up to 300 ft. from the thermistor and operates from the 240-v. 50-c's. supply.

"Versa-Tran controllers" are available for surface mounting, flush mounting, or mounting in most electrical enclosures. For full details, specification S1010-6 is available on request from Honeywell Controls Ltd., Ruislip Road East, Greenford, Middlesex.

Welding Electrode

COOPER AND TURNER LTD., of Vulcan Works, Vulcan Road, Sheffield, 9, have produced a 14-gauge electrode in the Ruby range of Diadem electrodes.

The coding of this 14-gauge electrode in B.S. 1719, is E217, it being a solid extruded, rutile based electrode suitable for use in all a.c. welding positions on mild steel, with an open circuit voltage of not less than 45 volts. Particular features of the electrode with regard to sheet metal welding are the easily controlled slag which allows either open arc or touch welding techniques to be employed, and a low degree of spatter.

The mechanical properties of the electrode include a yield point of 24/28 tons per sq. in., an ultimate tensile strength of 29/34 tons per sq. in., a carbon content in the range 0.08 to 0.10 per cent and a manganese content of between 0.55 and 0.65 per cent. The core diameter is 0.104 in. and the electrode is supplied in 12 in. lengths. The current range is 65 amp. minimum to 80 amp. maximum and the deposition rate at 72 amp. is 71.7 lb. per cwt. of electrode.

Stacking Trucks

AN interesting new range of stackers designed and produced in Sweden is now available in this country (Fig. 6). Known as the BT SV Stackers, they are pedestrian operated with an electro-hydraulic lift and have a capacity of 1,100 lb. or 2,200 lb. at a 24 in. load centre. Standard lift heights of 92, 108, 124 or 132 inches are available.

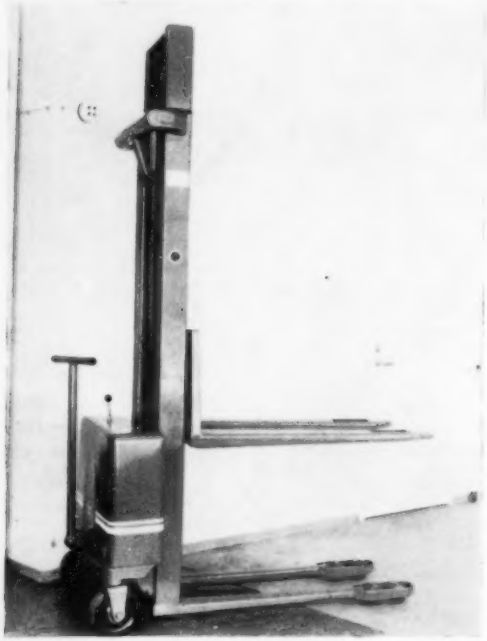
These trucks are suitable for operation in confined spaces and have a turning radius of 69 in. and an overall length of 63 in. including forks. They are also suitable for use where floor loading is restricted having an unladen weight of less than 900 lb.

Maximum rigidity and strength under full load is achieved by virtue of the fact all main components such as mast, lifting forks, mast channels, and support egs are one-piece pressings of high tensile steel. The hydraulic unit is claimed to be leak proof, incorporating special packing material which provides long and trouble-free service. Lifting speed is 33 ft. per min. with the ½-ton model and 16 ft. per min. with the 1-ton model. The lowering speed is adjustable. Single, telescopic and free lift masts can be supplied.

Mains operated models are available as an alternative to the battery-powered units and stackers with a manually-operated hydraulic system can also be provided.

Full details are available from the U.K. distributors, Rolatruc Ltd., 20, Old Compton Street, London, W.1.

Fig. 6.—Electro-hydraulic stacking truck



Hydraulic Press Brakes

FIG 7 illustrates a Bronx 120-ton hydraulic press brake 8 ft. between the columns and 12 ft. overall the beams including a 2-ft. horn extension on the left-hand side, which is one of a new range manufactured by the Bronx Engineering Co. Ltd., of Lye, nr. Surrey, incorporating the latest developments in hydraulic engineering. The design allows bends to be made with an accuracy guaranteed to be the equivalent to the results obtainable on a mechanical press brake, a feature unusual on a hydraulic machine and of the greatest value. Whether forming air bends or on bottoming operations the press cannot be overloaded and the rated tonnage is available throughout the stroke. Selector switches enable the machine to be set for continuous or single stroke operations, timed dwell or indefinite dwell at the bottom of the stroke and automatic reversal on reaching any preset tonnage. These machines are available in capacities of 120 to 750 tons.

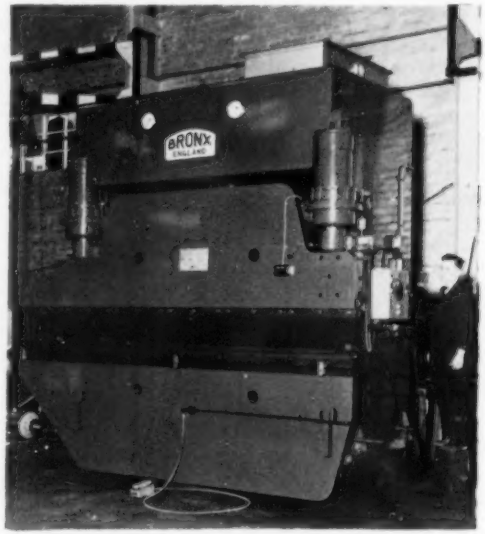


Fig. 7.—120-ton hydraulic press brake

Milling Steels

WICKMAN LTD., Wimet Division, have announced the introduction of a new grade designated Wimet XL35.

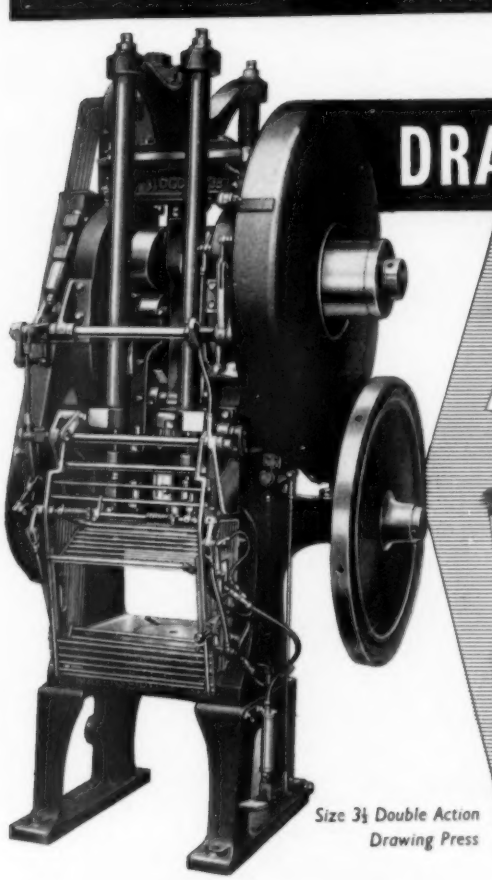
This is a grade of carbide combining to an unusual extent the characteristics of wear resistance and toughness, which has been developed over the last few years for milling steel. Despite its high hardness of approximately 1,500 V.P.N. it possesses a superior resistance to thermal cracking at the cutting edge, which has been achieved by the selection of correct grain structures. It is especially suitable for all face, slot and end milling operations on steel. These types of operation cause the greatest thermal shock because the cutting edge of the tool is heated rapidly to a high temperature whilst cutting, and suddenly cooled whilst passing through air. These tendencies are increased in operations such as slot milling where the chip thickness tapers to zero and a rubbing action accentuates these effects.

It can also be used with advantage on other operations such as intermittent turning where thermal shock is encountered.

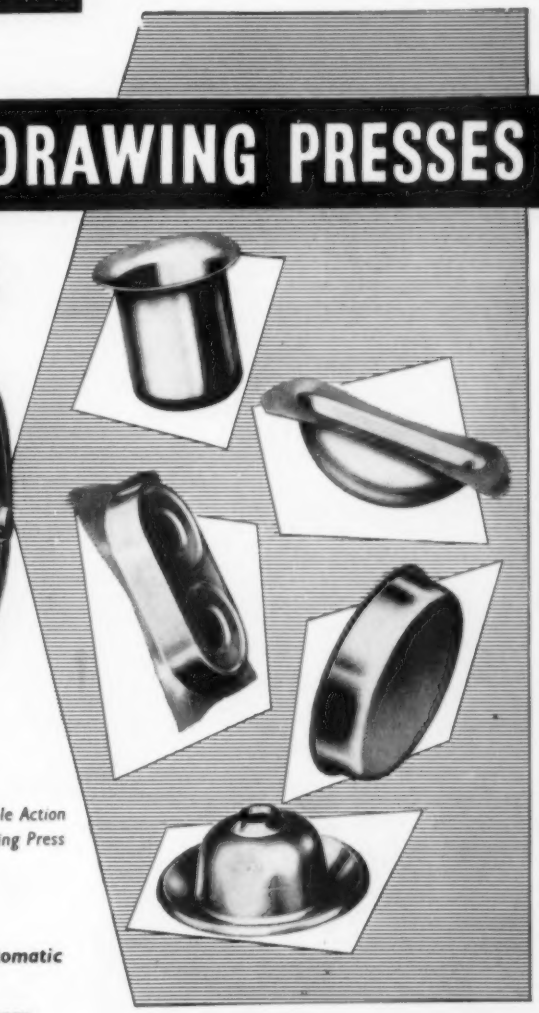
In a long testing programme it has been applied to crankshaft milling, milling slots of large and small rotors,

(*Continued in page* 558)

DOUBLE ACTION DRAWING PRESSES



Size 3½ Double Action Drawing Press



WE ALSO MAKE

Power Screw Presses
Open-fronted Presses
Double sided Presses
Single and Double Crank Presses

All types of Automatic Feed Presses
Minting machinery
Cartridge machinery

MEMBER

TAYLOR & CHALLEN LTD

BIRMINGHAM 19

and to a wide variety of die block milling, as well as innumerable intermittent turning operations. In all of these, tool life has been considerably extended in comparison with other grades.

Tips supplied in the new grade will carry a premium of 5 per cent.

Aircomatic Welding Gun

AIRCO CO. INTERNATIONAL, a Division of Air Reduction Co., Inc., 60, East 42nd Street, New York, has recently developed a new type, manual "Aircomatic" welding gun, designated Model "AH60 B" for use on mild steel using carbon dioxide as a shielding gas. (Fig. 8).

The new air-cooled gun has a continuous duty rating of 600 amp. d.c. when using "buried arc" CO_2 techniques. It can accommodate hard welding wires ranging from 0.035 in. to $\frac{5}{32}$ in. fed from conventional wire feeders.

The gun is equipped with a lever trigger for simple operation and has a goose-neck nozzle assembly for ease of welding in remote areas. The number of cable connections has been reduced by combining both the power cables and the wire casing. It is particularly effective where rugged applications and high duty cycles are likely to be encountered, No tools are required for disassembly and replacement parts are inexpensive.

Fig. 8.—Carbon-dioxide welding gun



Heating Electrode

A NEW electrode, Thermees, for applying a rapid and concentrated heat to metal before welding, bending or straightening, is announced by the English Electric Co. Ltd., Marconi House, Strand, London, W.C.2.

The electrode may be used on any standard metal and in any position. Heat can thus be applied in an exact spot and in normally inaccessible places without any special flame or induction heating equipment.

Thermees is handled like a normal electrode and requires no special equipment or technique. It can be used on a.c. or d.c. welding plant. For best results the a.c. supply should have an open-circuit voltage of 80 to 85 volts.

Temperature rise of the metal is regulated by the rate of travel and number of passes of the electrode. Any residual scale or oxide can easily be brushed off to leave the surface clean.

Thermees has been developed and is marketed by the Welding Electrode Division of English Electric at Accrington.

New Laboratory Balance

THE Griffin Minor Balance (Fig. 9) is the first of the new series of balances designed for general purposes but incorporating analytical features, produced by Griffin and George Ltd., Ealing Road, Alperton, Middlesex. It has a short beam for speedier weighing, single-limb bows carrying the weighing pans for unimpaired operation, an inclined scale which rises with the pointer and thus facilitates reading and avoiding parallax, a unique design in stirrups to protect knife edges, and a new design pillar allowing easy and rapid assembly.

The improved assembly of the agate bearings is extremely important because they are held in position by positioning screws instead of being "drifted in" which is the usual practice. When the beam is arrested all the agate bearings are relieved. This gives much longer life with students and in works control laboratories.

Fig. 9.—Laboratory balance



Combined Flanging Press and Guillotine Shear

PEARSON MACHINE TOOL CO. announce a new addition to their range of electro-hydraulic metal-working machinery in the shape of a combined flanging press and guillotine shear (Fig. 10). This is a single machine providing facilities both for shearing and press brake work. The shear operates on the normal down-stroking principle and the press is up-stroking. The combined machine thus gives the user advantages in saving of floor space and in capital outlay since it is substantially lower in price than would be the two separate

(*Continued in page* 560)



"FASTEX 5"

-the best electrode for most jobs

The Murex " Fastex 5 " electrode has many features which make it the best welding electrode for most jobs. It has exceptionally smooth running properties and general ease of operation in all welding positions. These are combined with low weld spatter and self-detaching slag. All these advantages ensure that high quality welds can be readily obtained for all general fabrication work, with neat and regular weld bead appearance and with freedom from undercut. Although primarily designed for flat and horizontal—vertical welding, the " Fastex 5 " electrode can be used in all other positions and is acknowledged by experienced engineers throughout the world as the best general purpose electrode for welding mild steel.

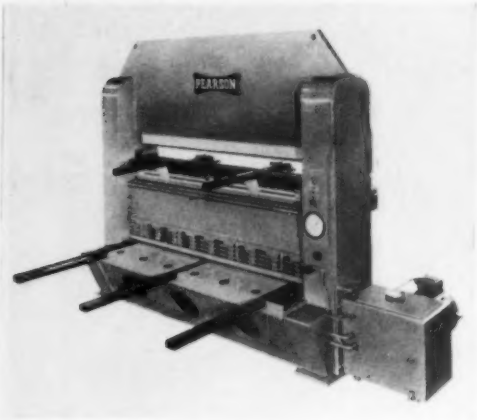
MUREX

MUREX WELDING PROCESSES LTD., WALTHAM CROSS, HERTS

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units of similar capacity; this will appeal to the smaller factories where both space and cost are of prime importance, and also to the maintenance departments of larger organizations who require a machine for use in their millwrights shop for a variety of purposes. Four models are offered: 100-ton press, 8 ft. by ¼ in. shear. 100-ton press, 10 ft. by ¼ in. shear. 125-ton press, 8 ft. by ¼ in. shear. 125-ton press, 10 ft. by ¼ in. shear.

Fig. 10.—*100-ton press: 8 ft. by ¼ in. shear*



Bench-mounted Ultrasonic Cleaning Equipment

FIG 11 shows one of a range of "Junior" bench-mounted general-purpose ultrasonic cleaning equipment manufactured by Kerry's (Ultrasonics) Ltd., Warton Road, Stratford, London, E.15, for cleaning small components such as ball bearing and ball race parts, etc., and for use in laboratories. The units operate at a frequency of 40 kc/s. with the transducers mounted into the base of a round stainless steel container which is in turn mounted on a skirt or plinth designed to enable the unit to either stand on the bench or be positioned into a conventional type watch cleaning machine. Components are cleaned in many cases without the necessity to dismantle, thereby avoiding chances of mechanical damage. Three standard sizes are available, all energized from an ultrasonic generator type L.325 giving an approximate power output of 250 watts pulsed.

Fig. 11.—*Bench-mounted ultrasonic cleaning equipment*



Automatic Punch Press

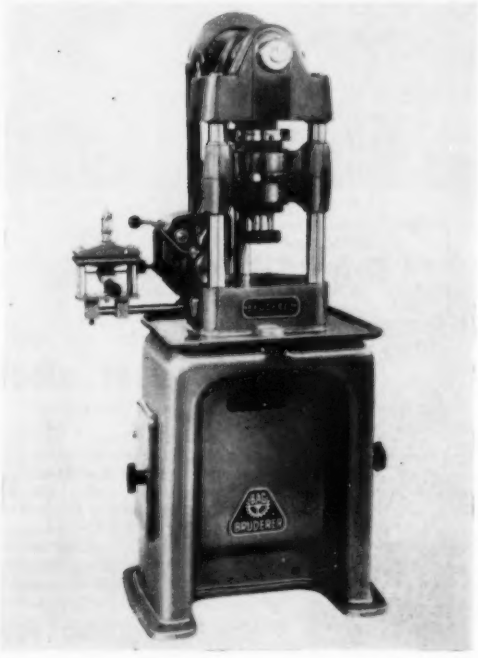
FIG. 12 illustrates an automatic punch press recently introduced in this country by Bruderer A.G. Arbon, Switzerland, for whom the sole agents are the Press and Shear Machinery Co. Ltd., 172-178, Victoria Road, Acton, London, W.3. The box principle of construction results in low weight and small volume for a press of this capacity, some 20 tons.

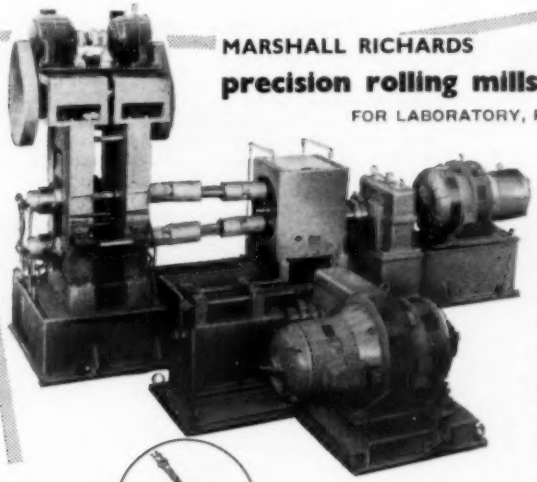
An interesting feature are the round pillar guides which are arranged in the form of an equilateral triangle with the chuck at the thrust point, making it impossible for the press frame to beam up on one of the sides as is the tendency with open presses. The pillars are tempered, ground and lapped, and the dowel bushes, made of special bronze, are precision turned, thus enhancing the bearing quality of the surfaces and minimizing abrasive wear.

There is no conventional spigot assembly and existing tools can be easily adapted for use by simply bolting them to a flat horizontal plate, combining with other features to give a tool life of some 5,000,000 presses and a high quality of the blanks produced.

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Fig. 12.—*Automatic punch press*





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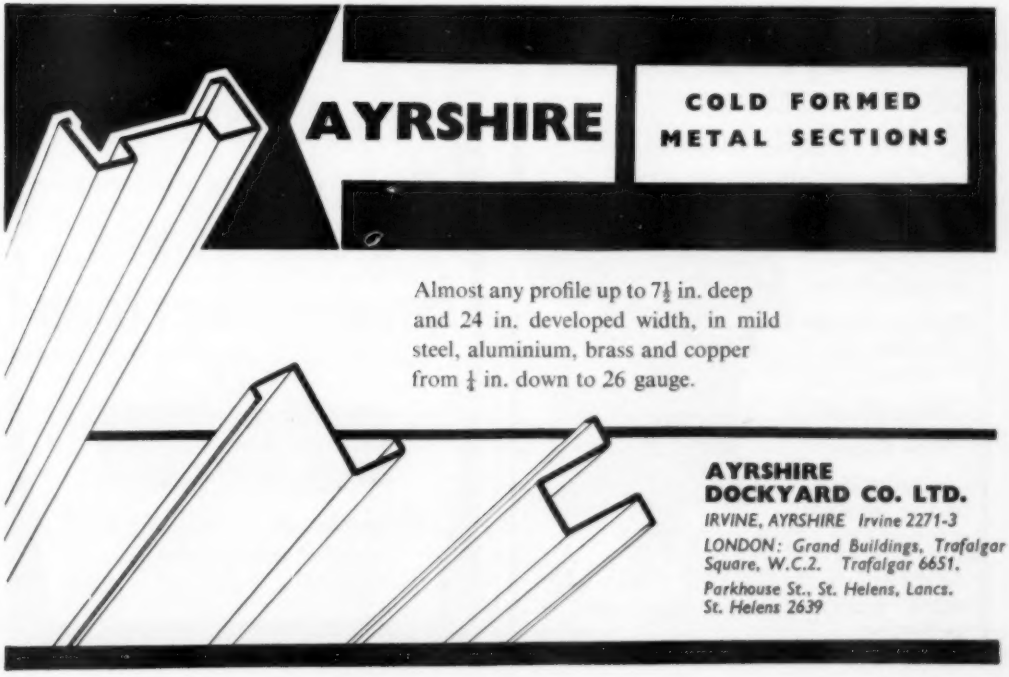
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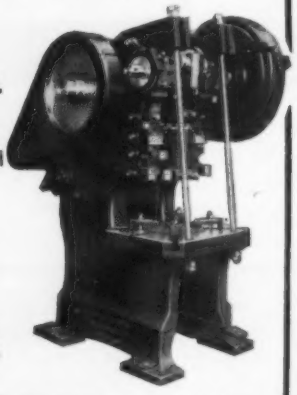


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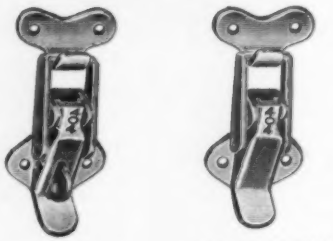
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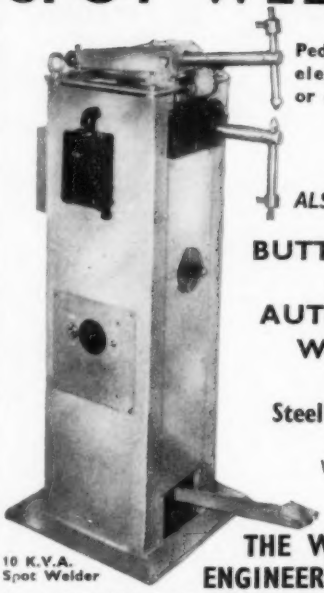
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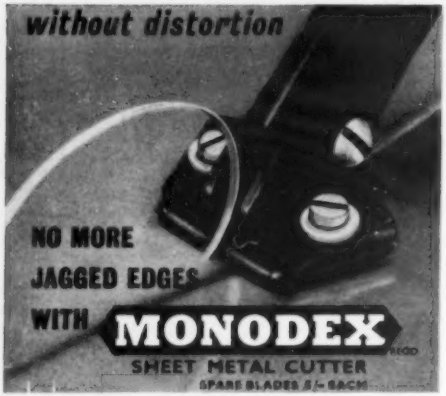
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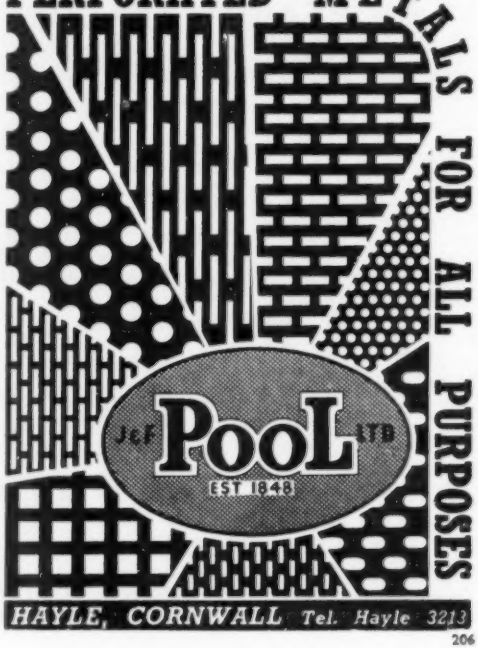
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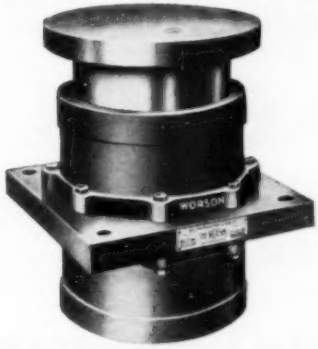


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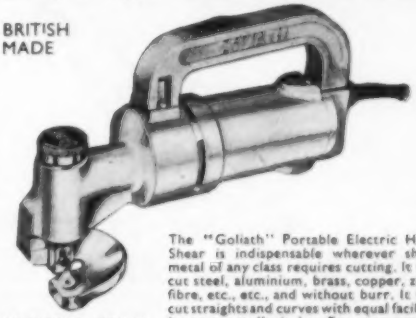
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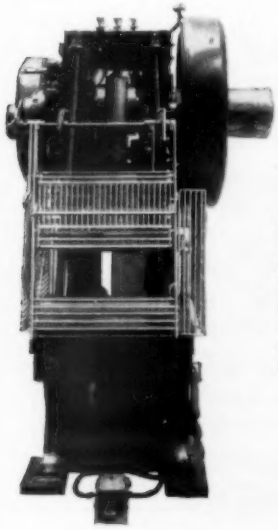
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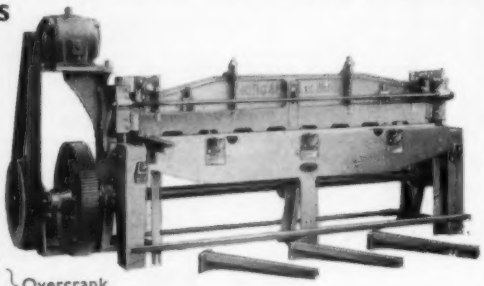
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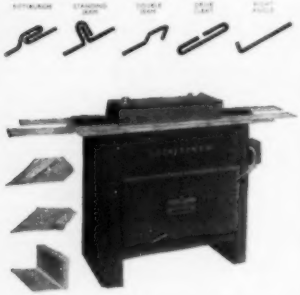


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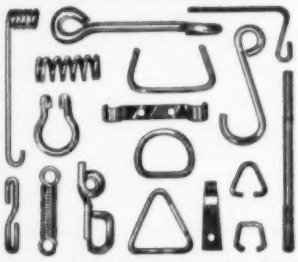
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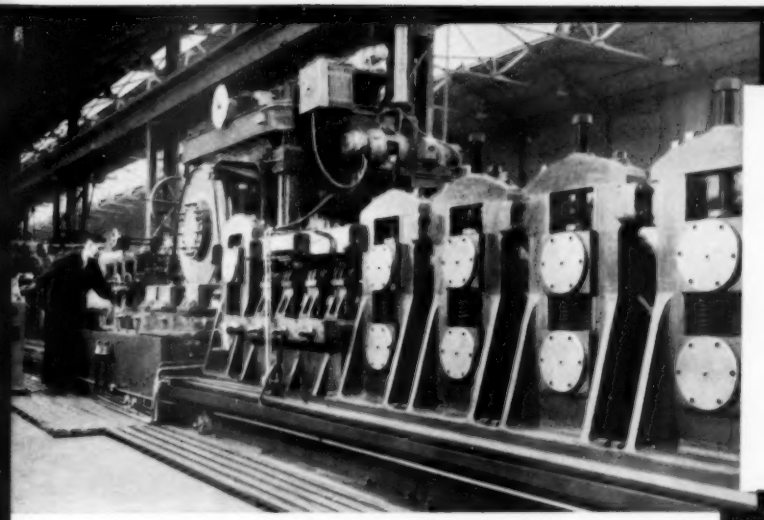
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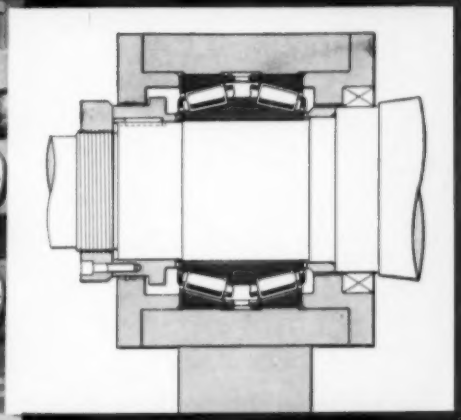
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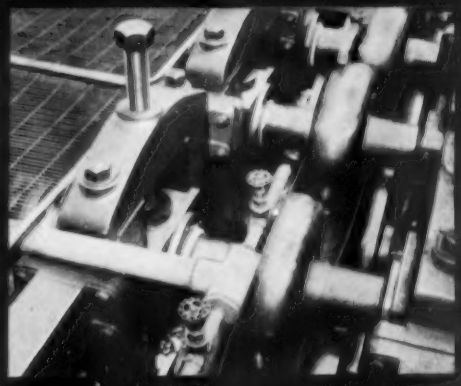
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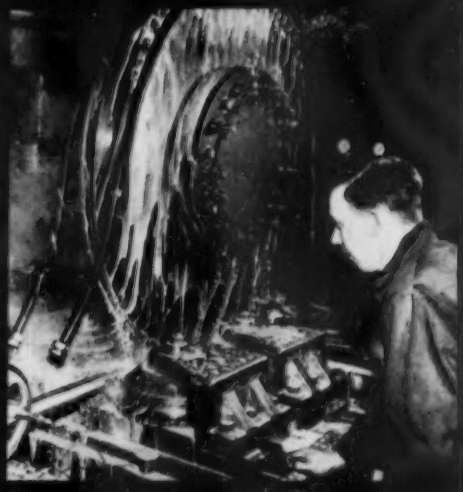
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Besco Truebend all-steel PRESS BRAKE



for your light and medium sheet metal bending and section forming and be very satisfied with the results—10 sizes in 20, 40, 60 and 80 tons capacities.

Their versatility is remarkable; in addition to forming in individual or progressive operations, using single or multiple dies and attachments, they will corrugate, bead, seam and wire; punch, notch, blank and pierce; emboss and press. Auxiliary equipment includes gauges and punching units.

Besco-Truebend Press Brakes are of steel plate construction, designed and built using only the best of today's features, materials and methods. Our leaflet 62M describes them [illegible] HP 459 tells of the F J.E Machine [illegible] you this new plant with no capital expense.

You should have these publications. May we send them to you?

Can be seen at Machine Tool Exhibition —Stand 8, Grand Hall, Olympia

Model No. Tons × die length	20/72	40/72	40/96	40/120	60/72	60/96	60/120	80/96	80/120	80/144
Bending capacity between frames	48" × 14 s.w.g.	48" × $\frac{1}{16}$"	72" × $\frac{1}{8}$"	96" × 14 s.w.g.	48" × $\frac{1}{8}$"	72" × $\frac{1}{16}$"	96" × $\frac{1}{8}$"	72" × $\frac{1}{8}$"	96" × $\frac{1}{16}$"	120" × $\frac{1}{8}$"
overall length	72" × 16 s.w.g.	72" × $\frac{1}{8}$"	96" × 14 s.w.g.	120" × 16 s.w.g.	72" × $\frac{1}{16}$"	96" × $\frac{1}{8}$"	120" × 12 s.w.g.	96" × $\frac{1}{16}$"	120" × $\frac{1}{8}$"	144" × 12 s.w.g.

F.J.Edwards Ltd

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Besco-Truebend is a registered name.
Registered Design No. 893331

